FRACTURE MECHANICS BASED OFFSHORE MOORING FATIGUE ASSESSMENT

Xutian XUE

A thesis submitted in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

in

Marine Technology

School of Engineering

Newcastle University, United Kingdom

September 2019

Abstract

Safety is crucially important for permanent offshore floating structures. However, over the past few decades, mooring accidents of permanent floating structures occurred at a high rate, and accident reports show that fatigue failure has become one of the most critical failure modes of mooring systems. There is thus a need to develop rational fatigue assessment approaches for offshore permanent mooring systems during the design phase.

In this thesis, a fracture mechanics (FM) based approach for offshore mooring fatigue assessment is developed, in which a mooring chain link is treated as a round bar, an initial surface crack is assumed to propagate at the surface of the chain link. Stress ranges are calculated based on the tension ranges of a mooring line subjected to the combined loading process induced by the motions of low-frequency (LF) and wave-frequency (WF). A comparison between T-N & S-N curves based fatigue assessment approaches and the developed FM based mooring fatigue assessment approach is made, and the results show that fatigue lives predicted by the three approaches are well comparable if the safety factors suggested by API and DNVGL are applied to T-N & S-N curves based approaches.

The developed FM based mooring fatigue assessment approach is then applied for mechanism investigation on mooring chain links subjected to out-of-plane bending (OPB), mooring chain links subjected to torque, and mooring chain links tensioned over a curved surface. The results show that the fatigue lives of mooring chain links are in general decreased significantly due to the effects of OPB and curved surfaces. In contrast, the effects of torque induced by the chain twist on fatigue lives of mooring chain links are not evident.

Finally, an investigation on the effects of load combination methods on fatigue lives of mooring chain links predicted by the FM based mooring fatigue assessment approach is also conducted. The results show that the FM based approach based on the narrow-band method generally offers the most conservative fatigue life prediction and the differences of fatigue lives of mooring chains estimated based on general wide-band methods and dual narrow-band methods are not obvious.

Keywords: offshore mooring, fatigue assessment, fracture mechanics, out-of-plane bending (OPB), torque, chain over curved surface, loading combination

Acknowledgments

Firstly, I would like to express my sincere gratitude to my respectable supervisor, Professor Nianzhong Chen for his distinguished supervision, guidance, encouragement, and support throughout this research. Without these, it would not be possible for me to complete this research.

My next thanks must go to another respectable supervisor, Dr Yongchang Pu, who has given me generous support and encouragement during these years.

Many thanks to Dr Yongyan Wu from Aker Solutions Inc., USA, for his valuable guide and discussion during this research.

My special and heartfelt thanks go to my precious family members for their spiritual and financial supports during these four years.

Finally, I am grateful to all those who have offered me encouragement and support during the course of my research.

Xutian XUE

September 2019

Table of contents

Abstract i
Acknowledgments iii
Table of contents v
List of figures ix
List of tables xiii
Nomenclature xv
Abbreviations xxi
List of publications xxiii
Chapter 1. Introduction 1
1.1 Background and motivation 1
1.2 Aims and objectives 4
1.3 Organisation of thesis 5
Chapter 2. Literature Review 7
2.1 Introduction 7
2.2 Mooring fatigue analysis for common mooring lines 7
2.2.1 Development of T-N/S-N curves for offshore mooring systems 7
2.2.2 T-N/S-N curves based mooring fatigue analysis for mooring lines 8
2.2.3 Fracture mechanism (FM) based mooring fatigue analysis 11
2.3 Mooring chain links subjected to Out-of-plane bending (OPB) 11
2.4 Mooring chain links subjected to torque 13
2.5 Mooring chain links tensioned over a curved surface 14
2.6 Load combination methods for offshore mooring fatigue assessment 15
2.7 Summary 16
Chapter 3. Mooring System Tension Analysis 17
3.1 Introduction 17
3.2 Mooring System Tension 17
3.2.1 Quasi-static low-frequency (LF) tension along mooring lines 17
3.2.2 Damping along mooring line 20
3.2.3 Dynamic analysis for wave-frequency (WF) tension 21
3.2.4 Combination of low-frequency (LF) and Wave-frequency (WF) mooring line tension 21
3.3 Case study 22
3.3.1 A semi-submersible 22
3.3.2 Hydrodynamic analysis for the Semi-Submersible 23
3.3.3 Description of designed mooring systems 26
3.3.4 Environmental loads considered in the mooring fatigue assessment 28
3.3.5 Results 30

Chapter 4. Fracture Mechanics (FM) based Fatigue Assessment for Mooring Lines Subjected to Pure Tension…. 33
4.1 Introduction 33
4.2 Palmgren-Miner's rule based fatigue analysis 33
4.2.1 T-N curves based fatigue analysis 33
4.2.2 S-N curves based fatigue analysis 35
4.3 Fracture mechanics analysis 36
4.3.1 Paris law and stress intensity factor 36
4.3.2 Finite element analysis 40
4.4 Comparison between T-N curves, S-N curves, and FM based fatigue analyses 45
4.5 Parametric study 52
4.5.1 Effect of initial crack shapes 53
4.5.2 Effect of initial crack sizes 54
4.5.3 Effect of critical crack depths 55
4.6 Summary 57
Chapter 5. Fracture Mechanics (FM) based Fatigue Assessment for Mooring Lines Subjected to Bending…… 59
5.1 Introduction 59
5.2 Fracture mechanics analysis for mooring chain links subjected to out-of-plane bending (OPB)……. 59
5.2.1 Out-of-plane bending (OPB) of mooring chain link 62
5.2.2 Finite element analysis of mooring chain links subjected to OPB 66
5.2.3 Results and discussion 70
5.2.4 Summary 82
5.3 Fracture mechanics analysis for mooring chain links subjected to torque 83
5.3.1 Torque of mooring chain link 83
5.3.2 Finite element analysis of mooring chain links subjected to torque 84
5.3.3 Results and discussion 85
5.3.4 Summary 88
5.4 Fracture mechanics analysis for mooring chain links tensioned over a curved surface 88
5.4.1 Mooring chain links tensioned over a curved surface 88
5.4.2 Finite element analysis of mooring chain link tensioned over curved surface 92
5.4.3 Results and discussion 95

5.4.4 Summary 103
5.5 Summary 104
Chapter 6. Effects of the Load Combination Method on a Fracture Mechanics Based Mooring Fatigue Assessment 105
6.1 Introduction 105
6.2 Combination of LF and WF tensions 105
6.2.1 Narrow-band method 106
6.2.2 General wide-band methods 107
6.2.3 Dual narrow-band methods 108
6.3 Results and discussion 110
6.4 Summary 117
Chapter 7 Conclusions and Recommendations 119
7.1 Conclusions 119
7.2 Recommendations and future work 120
Appendixes…… 123
Appendix A: Data of mooring line tensions of designed mooring system A 124
Appendix B: Data of mooring line tensions of designed mooring system B 148
Appendix C: Data of mooring line tensions of designed mooring system C 172
Appendix D: Data of mooring line tensions of designed mooring system D 196
References……. 220

List of figures

Figure 1.1: Floating structures for offshore drilling or production (Kaiser, 2019) 1
Figure 1.2: Causes of failure event for mooring systems (Fontaine et al, 2014)..... 3
Figure 3.1: Geometry of a 2D catenary mooring line 18
Figure 3.2 Geometry of a 2D taut mooring line 19
Figure 3.3: Geometry of the semi-submersible 23
Figure 3.4: Morison model (Left) and panel model (right) of the semi-submersible..... 24
Figure 3.5: Dual model in hydrodynamic analysis..... 25
Figure 3.6 RAOs of the semi-submersible in six degrees of freedom..... 25
Figure 3.7: catenary mooring systems (left) and taut mooring systems (right)..... 26
Figure 3.8: Detailed arrangement of 16 mooring lines serviced in the platform..... 27
Figure 3.9 Displacement RAOs of mooring line in the direction consistent with the waves for each case 32
Figure 3.10 Tension RAOs of mooring line in the direction consistent with the waves for each case . 32
Figure 4.1: T-N curves for mooring lines and components (API RP 2SK, 2008)..... 34
Figure 4.2: S-N curves for mooring lines and components (DNVGL OS E301, 2015)..... 36
Figure 4.3: Geometry of a round bar with a semi-elliptical crack (a/r≪1) 37
Figure 4.4: Geometry of a round bar with a surface semi-circle crack ($a/r \ll 1.2$) 39
Figure 4.5: Finite element model of mooring chain links 40
Figure 4.6: Meshed contact elements of mooring chain links..... 41
Figure 4.7: Locations of a chain link subjected to pure tension prone to fatigue damage 42
Figure 4.8: Normal stresses at locations of the chain link prone to potential fatigue damage: (a) weld section; (b) bend section; (c) crown section 43
Figure 4.9: Linearization of stress distribution over a cross-section: (a) weld section; (b) bend section; (c) crown section 45
Figure 4.10: T-N curves, S-N curves, and fracture mechanics based fatigue analyses for mooring chain links subjected to the combined low-frequency and wave-frequency tension for Case A: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line 16 47
Figure 4.11: T-N curves, S-N curves, and fracture mechanics based fatigue analyses for mooring chain links subjected to the combined low-frequency and wave-frequency tension for Case B: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (c) Line 9 to Line 12; (d) Line 13 to Line 16 48
Figure 4.12: T-N curves, S-N curves, and fracture mechanics based fatigue analyses for mooring chain links subjected to the combined low-frequency and wave-frequency tension for Case C: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line 16 50

Figure 4.13: T-N curves, S-N curves, and fracture mechanics based fatigue analyses for mooring chain links subjected to the combined low-frequency and wave-frequency tension for Case D: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line 16 51
Figure 4.14: Fracture mechanics based fatigue analyses for mooring chain links with initial semi-elliptical surface cracks and initial semi-circle surface cracks for Case A: (a) Line 1 to Line 8; (b) Line 9 to Line 16 53
Figure 4.15: Fracture mechanics based fatigue analyses for mooring chain links with different initial crack sizes $(a0, c0)$ for Case A: (a) Line 1 to Line 8; (b) Line 9 to Line 16 55
Figure 4.16: Fracture mechanics based fatigue analyses for mooring chain links with different critical crack depths for Case A: (a) Line 1 to Line 8; (b) Line 9 to Line 16 56
Figure 4.17: Crack evolution of the crown section of mooring chain link at the Line 4 fairlead in Case A 57
Figure 5.1: Bending modes of mooring chain link: (a) IPB mode; (b) OPB mode; (c) Torque mode 61
Figure 5.2: Mooring chain links subjected to OPB 62
Figure 5.3: Sketch of mooring chain laying on the chain wheel 63
Figure 5.4: Sketch of mooring chain passing over the bending shoe 64
Figure 5.5: Sketch of mooring chain constraint provided by the chain hawse 65
Figure 5.6: Sketch of mooring chain constraint provided by the chain stopper 66
Figure 5.7: Finite element model of the scenario that mooring chain link laying on the chain wheel . 67
Figure 5.8: Finite element model of the scenario that mooring chain links passing over the bending shoe 68
Figure 5.9: Finite element model of mooring chain links constraint provided by the chain hawse 69
Figure 5.10: Finite element model of mooring chain links constraint provided by the chain stopper . 70
Figure 5.11: sketch of mooring chain links 71
Figure 5.12: Stress distribution of the mooring chain link subjected to OPB laying on the chain wheel: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue 73
Figure 5.13: The ratios of fatigue lives of crown sections of mooring chain links laying on 5-pocket, 7-pocket, and 9-pocket chain wheels to those not subjected to OPB 73
Figure 5.14: Stress distribution of the mooring chain link subjected to OPB passing over the bending shoe: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue 75
Figure 5.15: The ratios of fatigue lives of weld sections of mooring chain links passing over bending shoes considering tracks with diameters of 5 m, 7 m and 9 m to those not subjected to OPB 76
Figure 5.16: Stress distribution of the mooring chain link subjected to OPB constraint provided by the chain hawse: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue 78
Figure 5.17: The ratios of fatigue lives of crown sections of mooring chain links constraint provided by chain hawses with diameters of 0.760 m, 0.912 m and 1.064 m to those not subjected to OPB..... 78

Figure 5.18: Stress distribution of the mooring chain link subjected to OPB constraint provided by the chain stopper: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue .. 81
Figure 5.19: The ratios of fatigue lives of mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 degrees to those not subjected to OPB 81
Figure 5.20: Sketch of mooring chain links subjected to torque..... 83
Figure 5.21: FE model and boundary conditions of mooring chain links with twist angle..... 85
Figure 5.22: Stress distribution of the mooring chain link subjected to OPB constraint provided by the chain stopper: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue .. 87
Figure 5.23: The ratios of fatigue lives of mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 degrees to those not subjected to torque 87
Figure 5.24: Three types of curved surfaces: (a) Ungrooved surface; (b) Shallow grooved surface; (c) Deep grooved surface..... 89
Figure 5.25: Sketch of half a mooring chain tensioned over an ungrooved surface 90
Figure 5.26: Sketch of half an upright mooring chain tensioned over a shallow grooved surface 91
Figure 5.27: Sketch of half a flat mooring chain tensioned over a deep grooved surface 92
Figure 5.28: FE model and boundary conditions of mooring chain links tensioned over an ungrooved surface..... 93
Figure 5.29: FE model and boundary conditions of mooring chain links tensioned over a shallow surface 94
Figure 5.30: FE model and boundary conditions of mooring chain links tensioned over a shallow grooved surface 94
Figure 5.31: Stresses of mooring chain link tensioned over an ungrooved surface: (a) Maximum principal stress; (b) normal stress at the critical location prone to fatigue..... 97
Figure 5.32: The ratios of fatigue lives of weld sections of mooring chain links tensioned over ungrooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m to those not tensioned over a curved surface 97
Figure 5.33: Stresses of mooring chain link tensioned over a shallow grooved surface: (a) Maximum principal stress; (b) normal stress at the critical location prone to fatigue..... 100
Figure 5.34: The ratios of fatigue lives of weld sections of mooring chain links tensioned over shallow groove surface with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m to those not tensioned over a curved surface 100
Figure 5.35: Stresses of mooring chain link tensioned over a deep grooved surface: (a) Maximum principal stress; (b) normal stress at the critical location prone to fatigue..... 102
Figure 5.36: The ratios of fatigue lives of weld sections of mooring chain links tensioned over deep groove surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m to those not tensioned over a curved surface 103

Figure 6.1: Ratios of fatigue lives predicted by the FM analysis based on wide-band methods to those based on the narrow-band method at crown sections of mooring chains: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line12; (d) Line13 to Line 16. 112
Figure 6.2: Ratios of fatigue lives predicted by the FM analysis based on wide-band methods to those based on the narrow-band method at bend sections of mooring chains. (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line 16. 113
Figure 6.3: Ratios of fatigue lives predicted by the FM analysis based on wide-band methods to those based on the narrow-band method at weld sections of mooring chains. (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line16. 114

List of tables

Table 1.1: Comparison of typical permanent mooring system and temporary mooring system (Subrata and Cliakrabarti, 2005) 2
Table 3.1: Principle dimensions of columns and pontoon of the semi-submersible 22
Table 3.2: Designed mooring systems 28
Table 3.3: Mooring line characteristics 28
Table 3.4: Sea states of the central of Gulf of Mexico 31
Table 4.1: Parameters of M and K for mooring components (T-N curves) (API RP 2SK, 2008) 34
Table 4.2: Parameters of M and K for mooring components (S-N curves) (DNVGL OS E301, 2015) 36
Table 4.3: Stress intensity magnification factors Mmat the deepest point (a) of a semi-elliptical surface crack in a round bar (BS7910, 2013) 38
Table 4.4: Stress intensity magnification factors Mm at surface(c) of a semi-elliptical surface crack in a round bar (BS7910, 2013) 38
Table 4.5: Stress intensity magnification factors Mbat the deepest point (a) of a semi-elliptical surface crack in a round bar (BS7910, 2013) 38
Table 4.6: Stress intensity magnification factors Mb at surface(c) of a semi-elliptical surface crack in a round bar (BS7910, 2013) 38
Table 5.1: SCFs and locations of hot spots on mooring chain links laying on 5-pocket, 7-pocket, and 9-pocket chain wheels 72
Table 5.2: SCFs and locations of hot spots on mooring chain links passing over bending shoes considering tracks with diameters of 5 m, 7 m and 9 m 74
Table 5.3: SCFs and locations of hot spots on mooring chain links constraint provided by chain hawses with diameters of 0.760 m, 0.912 m and 1.064 m 77
Table 5.4: SCFs of hot spots on mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 with friction coefficient of 0.1 79
Table 5.5: SCFs of hot spots on mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 with friction coefficient of 0.3 80
Table 5.6: SCFs of hot spots on mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 with friction coefficient of 0.5 80
Table 5.7: SCFs of hot spots on mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 with friction coefficient of 0.5 86
Table 5.8: SCFs of hot spots on mooring chain links laying on ungrooved surfaces with diameters of 2.5m, 3.0 m, 3.5 m and 4.0 m with $\beta = 45°$ 95
Table 5.9: SCFs of hot spots on mooring chain links laying on ungrooved surfaces with diameters of 2.5m, 3.0 m, 3.5 m and 4.0 m with $\beta = 40°$ 96

Table 5.10: SCFs of hot spots on mooring chain links laying on ungrooved surfaces with diameters of 2.5m, 3.0 m, 3.5 m and 4.0 m with $\beta = 35°$ 96
Table 5.11: SCFs of hot spots on mooring chain links laying on shallow grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m 99
Table 5.12: SCFs of hot spots on mooring chain links laying on deep grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m 101
Table 6.1: Relative differences between fatigue lives predicted by the FM analysis based on Dirlik method and dual narrow-band methods 115
Table 6.2: Relative differences between fatigue lives predicted by the FM analysis based on Tovo and Benasciutti method and dual narrow-band methods 116
Table 6.3: Relative differences between fatigue lives predicted by the FM analysis based on the narrow-band method and wide-band methods for some special cases 117

Nomenclature

A	Area of cross - section
A_C	Project area of the surface perpendicular to current
A_W	Project area of the surface perpendicular to wind
B	Breadth of mooring chain link
C	Material constant
C_D	Drag coefficient
C_{dl}	Longitudinal drag coefficient
C_{dn}	Normal drag coefficient
C_M	Matrix of damping
D	Fatigue damage
D_{NB}	Fatigue damage estimated by the narrow-band method
D_{RC}	Range counting damage intensity
D_i	Fatigue damage for each sea state
D_s	Diameter of curved surface
$E()$	Mean value function
F_C	Current load
F_P	Proof loading
F_W	Wind load
F_{Fri}	Friction between adjacent mooring chain links
F_{normal}	Contact force
F_Φ	Tangential mooring line damping
F_Ψ	Normal mooring line damping

$G(f)$	Spectral density function
H_s	Significant wave height
L	Length of mooring chain link
L_{Dual}	Fatigue life of a mooring chain link calculated based on the dual narrow-band method
L_{GW}	Fatigue life of a mooring chain link calculated based on the general wide-band method
L_N	Fatigue life of a mooring chain link calculated based on the narrow-band method
L_S	Scale length
L_W	Fatigue life of a mooring chain link calculated based on the wide-band method
M	slope of a T-N curve/S-N curve
M_M	Matrix of mass
$\mathrm{M_m}$	Stress intensity magnification factor
M_{opb}	Out-of-plane bending moment
N_i	Number of cycles to failure
Q	Torque
$S_J()$	Spectrum function of Jonswap spectrum
S_{Ri}	Stress range
$S_W()$	Spectrum function of Harris spectrum
T	Mooring line tension
T_D	Dynamic mooring line tension
T_H	Horizontal mooring line tension at the fairlead
T_L	Mooring line tension at fairlead subjected to low-frequency motion

T_M	Mean mooring line tension
T_{Ri}	Tension range
T_W	Mooring line tension at subjected to wave-frequency motion
K	Intercept parameter
K_{IC}	Stress intensity factor
K_M	Matrix of stiffness
U_{10}	Mean wind speed at 10m above sea level
V_C	Current speed
V_W	Wind speed
X	Horizontal distance from touch down point to the fairlead
$X(t)$	Combined loading process
$X_L(t)$	Low-frequency loading process
$X_W(t)$	Wave-frequency loading process
Z	Vertical distance from seabed to the fairlead
a	Crack depth
a_0	Initial crack depth
a_c	Critical crack depth
c	Half crack length
d	Nominal diameter of mooring chain link
d_i	Diameter of each mooring component
f	Frequency in hertz
f_W	Wind frequency
$f()$	Probability density function
g	Acceleration of gravity
i	Mooring component number

k	Surface roughness coefficient
k_{normal}	Contact stiffness
l_i	Suspended length of each mooring component
m	Material constant
m_n	nth order spectral moment
n_i	number of cycles in the loading process
r	Displacement vector from the mean position
t	Shell thickness
v_0	Zero up-crossing frequency of tension process
v_{Ci}	Zero up-crossing frequency of combined tension process for each sea state
v_p	Peak frequency of tension process
v_{Li}	Zero up-crossing frequency of the low-frequency tension process for each sea state
v_{Wi}	Zero up-crossing frequency of the wave-frequency tension process for each sea state
w	Weight factor
w_i	Unit mooring line wet weight of each mooring component
x_i	Projected horizontal length of each suspended mooring component
$x_{penetration}$	Penetration
z_i	Projected vertical depth of each suspended mooring component
$\Gamma(\,)$	Gamma function
$\Phi(l)$	Displacement along the mooring line
$\Psi(l)$	Displacement normal to the mooring line
α	Interlink angle

α_1	Bandwidth of load spectrum
α_J	Spectrum parameter in Jonswap spectrum
β_J	Spectrum parameter in Jonswap spectrum
ΔK_a	Stress intensity factor ranges
ΔK_c	Stress intensity factor ranges
σ_J	Spectrum parameter in Jonswap spectrum
σ_{Li}	Standard deviation of the low - frequency tension process for each sea state
σ_{Si}	Standard deviation of the nominal stress ranges for each sea state
σ_{Wi}	Standard deviation of the wave - frequency tension process for each sea state
σ_b	Bending stress
σ_i	Standard deviation of the combined tension process for each sea state
σ_m	Membrane stresses
σ_{nor}	Normal stress
θ_F	Mooring line angle from horizontal at fairlead
θ_i	Mooring line angle from horizontal of each suspended mooring component
θ_0	Mooring line angle from horizontal at the anchor point
ρ	Water density
ρ_a	Air density
ω	Frequency in rad/s
ω_p	Peak frequency in rad/s

Abbreviations

FEA	Finite element analysis
FEM	Finite element method
FM	Fracture mechanics
FPSO	Floating production storage and offloading
GoM	Gulf of Mexico
IPB	In-plane bending
JIP	Joint Industry Project
LF	Low-frequency
OPB	Out-of-plane bending
RAO	Response amplitude operator
RBS	Reference breaking strength
SCF	Stress concentration factor
SIF	stress intensity factor
semi	Semi-submersible
spar	Surface-piercing articulated riser
TDP	Touchdown point
TLP	Tension leg platform
WF	Wave-frequency

List of publications

Journal papers

- Xue, X., Chen, N.Z. (2018). Fracture mechanics analysis for a mooring system subjected to Gaussian load processes. **Engineering Structures**, 162, 188-197.
- Xue, X., Chen, N.Z., Wu, Y., Xiong, Y., Guo, Y. (2018). Mooring system fatigue analysis for a semi-submersible. **Ocean Engineering**, 156, 550-563.
- Xue, X., Chen, N.Z., Pu. Y., Gao, X. (2019). Fracture mechanics analysis for mooring chain links subjected to out-of-plane bending (OPB). **Marine Structures.** (under review)
- Xue, X., Chen, N.Z., Pu. Y. (2019). Mooring fatigue assessment for a semi-submersible in Offshore West Africa (OWA). **Engineering Failure Analysis.** (under review)
- Xue, X., Chen, N.Z., Pu. Y. (2019). Fracture mechanics assessment for mooring chain links tensioned over curved surfaces.(To be submitted)

Proceedings of conferences

- Xue, X., Chen, N.Z., Pu. Y. (2019). Fracture mechanics based mooring chain fatigue analysis for a semi-submersible subjected to triple narrow-band loading processes. In: the 38th International Conference on Ocean, Offshore & Arctic Engineering (**OMAE**). Glasgow, UK.
- Xue, X., Chen, N.Z., Pu. Y. (2019). Effects of proof loading test on fatigue life of mooring chain links. In: the 7th International Conference on Marine Structures (**MARSTRUCT**). Dubrovnik, Croatia.
- Xue, X., Chen, N.Z. (2018). Fracture mechanics based mooring chain fatigue analysis for a semi-submersible subjected to tension and torque. In: the 37th International Conference on Ocean, Offshore & Arctic Engineering (**OMAE**). Madrid, Spain.
- Xue, X., Chen, N.Z. (2017). T-N curves and fracture mechanics based mooring fatigue analysis for a semi-submersible. In: the 36th International Conference on Ocean, Offshore & Arctic Engineering (**OMAE**). Trondheim, Norway.
- Xue, X., Chen, N.Z. (2017). Fracture mechanics analysis for a mooring system subjected to tension and out-of-plane bending. In: the first Conference of Computational methods in Offshore Technology (**COTech**). Stavanger, Norway.
- Xue, X., Chen, N.Z. (2017). Palmgren–miners' rule and fracture mechanics based fatigue analysis of deepwater mooring lines. In: the 6th International Conference on Marine Structures (**MARSTRUCT**). Lisbon, Portugal.

Chapter 1. Introduction

1.1 Background and motivation

Around the 1890s, the first offshore oil wells were drilled in the portion of Summerland field in California, America. With the subsequent discoveries of a large amount of offshore oil/gas fields around the worldwide, the demand on offshore units for oil/ gas drilling and production has increased over the past decades.

Due to the high demand for the oil and gas worldwide, offshore operations have expanded and moved to deepwater and ultra-deepwater. Offshore drilling or production in deepwater and ultra-deepwater requires that operations should be carried out from floating structures, as fixed structures are limited to a water depth of about 1000 ft - 1800 ft (305 m - 549 m). Nowadays, floating structures for drilling or production can be primarily categorized into four main classes: floating production storage and offloading (FPSO), semi-submersible (semi), surface-piercing articulated riser (spar), and tension leg platform (TLP), as shown in Figure 1.1 (Kaiser, 2019).

Figure 1.1: Floating structures for offshore drilling or production (Kaiser, 2019)

An offshore mooring system is designed for securing the offshore platform to an operating location with specific requirement associated with oil/gas drilling and production. Depending

on the designed duration of the offshore operation, offshore mooring systems can be grouped into a temporary mooring system and a permanent mooring system. The temporary mooring system is usually designed for drilling vessels, pipe laying vessels, lift vessels, etc. The permanent mooring system is required by the long-term floating structure, e.g. FPSO, production semi-submersible. In general, the permanent mooring system holds more restrictively standards than the temporary mooring system. The main differences are listed in Table 1.1 (Subrata and Cliakrabarti, 2005).

Table 1.1: Comparison of typical permanent mooring system and temporary mooring system (Subrata and Cliakrabarti, 2005)

Permanent mooring system	**Temporary mooring system**
Design for 100-yr return period events	Design for 50-yr return period events
Moorings are usually not slacked in storm events	Moorings are slacked in storm events
Components designed for > 10 years life	Components designed for < 10 years life
Fatigue analysis required	Fatigue analysis not required
Line dynamics analysis required	Line dynamics analysis not required
Accident analysis required	Accident analysis not required

Safety is crucially important for offshore floating structures. However, over the past few decades, mooring accidents of permanent floating structures occurred at a high rate (Majhi and D'Souza, 2013; Ma et al., 2013; Fontaine et al., 2014). HSE (1992) reviewed the causes of 8 mooring incidents in the storms of October 1991 and January 1992. Borwn et al. (2005) investigated several mooring accidents occurred from 1981 to 1994, and discussed the potential causes and consequences of mooring failure. Majhi and D'Souza (2013) concluded the mooring failures and pre-emptive action from 2000 to 2012, and they reported that at least 20 assets have integrity issues, and at least 150 mooring lines are replaced or repaired. Ma et al. (2013) reported that 23 mooring failures happened from 2001 to 2011, and Kvitrud (2014) reviewed 15 mooring failures in the Norwegian Sea from 2010 to 2013. Fontaine et al. (2014) presented the result of an industry survey of mooring line failure, and they pointed out that at least 107 mooring failure

from 73 assets occurred from 1997 to 2013. Given the substantial increase in the number of offshore structures, the number of offshore mooring incidents might be increased in the future.

Ma et al. (2013), Kvitrud (2014) and Fontaine et al. (2014) concluded that most of the mooring system failures are due to the failures of mooring chain links, and the fatigue failure is one of the critical failure modes of mooring chain links. In particular, Fontaine et al. (2014) reported that 46% of mooring system failures reported in 1997 to 2013 are due to mooring chain, and 44% of mooring chain failures are related to fatigue, as shown in Figure 1.2. There is thus a pressing need to develop rational mooring fatigue assessment approaches for offshore mooring chains during the design phase.

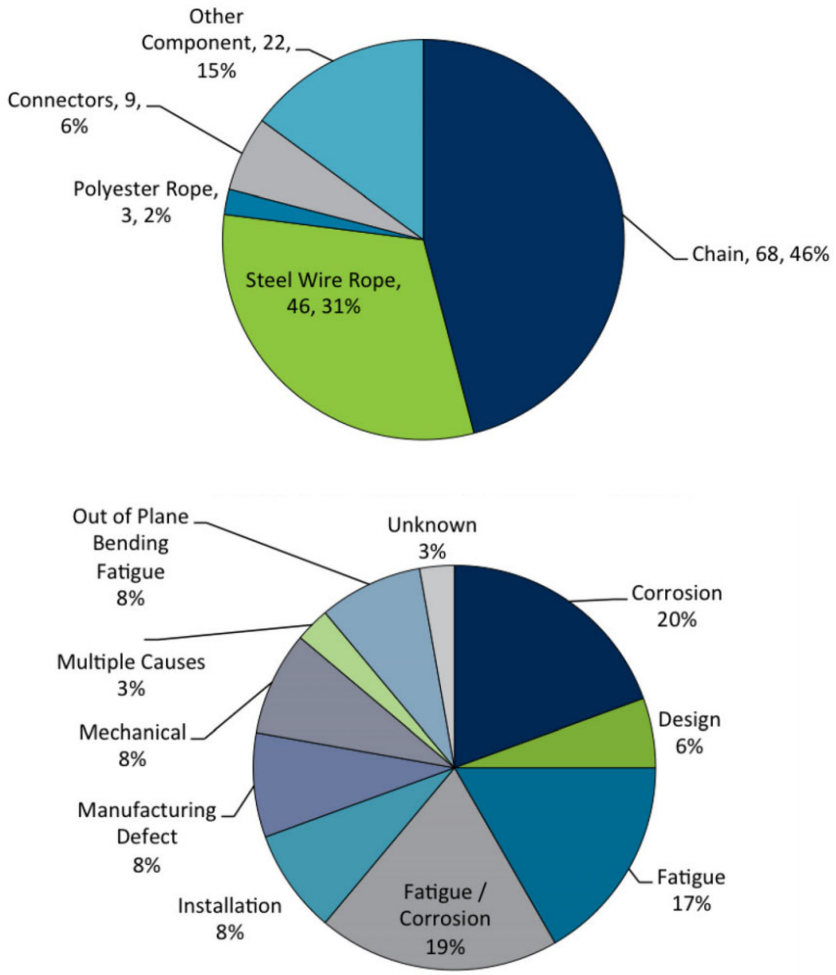


Figure 1.2: Causes of failure event for mooring systems (Fontaine et al, 2014)

Traditionally, offshore mooring chain fatigue assessment is performed using the T-N/S-N curves based approaches. However, as aforementioned, mooring accidents of permanent floating structures occurred at a high rate over the past few decades, which indicates that the validity of the T-N/S-N curves based approaches for offshore mooring fatigue assessment should be re-evaluated, or there is a need to develop new offshore mooring fatigue assessment approaches. In addition, API codes (API RP 2SK, 2008) point out that the fatigue of mooring chain links subjected to bending should be evaluated carefully, especially for mooring systems designed for permanent platforms. However, the T-N/S-N curves based approaches can only predict fatigue damage for mooring chain links subjected to pure tension. Therefore, to solve these problems, this thesis aims to develop a new approach, namely a fracture mechanics (FM) based approach, for offshore mooring fatigue assessment.

1.2 Aims and objectives

The overall aim of this thesis is to develop a fracture mechanics (FM) based mooring fatigue assessment approach for offshore permanent mooring systems.

The objectives of this thesis are:

- To develop an FM based fatigue assessment approach for offshore permanent mooring systems;
- To conduct a comparative study between T-N & S-N curves based approaches and the developed FM based approach for fatigue assessment for offshore permanent mooring systems;
- To perform a parametric study on the effects of the variation of initial crack shapes, initial crack sizes, and critical crack depth on fatigue life of a mooring line;
- To investigate the effects of out-of-plane bending (OPB) on fatigue lives of mooring chain links. Mooring chain links laying on the chain wheel, chain links passing over the bending shoe, chain links constraint provided by the chain hawse, chain links constraint provided by the chain stopper, are considered;
- To investigate the effects of torque induced by chain twist on fatigue lives of mooring chain links;

- To investigate the effects of the ungrooved surface, shallow grooved surface and deep grooved surface on fatigue lives of mooring chain links tensioned over the three curved surfaces (the definitions of curved surfaces can be found in Section 5.4.1);
- To conduct an investigation on the effects of load combination methods on fatigue lives of mooring chain links predicted by the developed FM based mooring fatigue assessment approach.

1.3 Organisation of thesis

This thesis consists of seven chapters.

Chapter 1 introduces the research background and motivation, the overall aim of this thesis, objectives of this thesis, and the organisation of the thesis.

Chapter 2 presents a literature review including research progress in the field of T-N & S-N curves based mooring fatigue analysis, FM based fatigue analysis, fatigue assessment for mooring chains subjected to OPB, fatigue assessment for mooring chains subjected to torque, fatigue assessment for mooring chains tensioned over a curved surface, and load combination methods for mooring fatigue assessment.

Chapter 3 introduces the theories and methodologies to predict the mooring line tension of an offshore permanent mooring system. A case study of mooring system analysis for a four-column ring pontoon semi-submersible operated at the Gulf of Mexico is presented in this Chapter.

Chapter 4 develops an FM based mooring fatigue assessment approach for offshore mooring systems. A comparative study on T-N & S-N curves based approaches and the developed FM based approach is made and a parametric study to investigate the impact of initial crack shape, critical crack depth, and initial crack sizes on fatigue life of a mooring chain link is also conducted.

Chapter 5 investigates the mechanism of mooring chain subjected to OPB, mooring chain links subjected to torque, mooring chain links tensioned over a curved surface, and the effects of OPB, torque induced by chain twist, and curved surfaces on fatigue lives of mooring chain links.

Chapter 6 conducts an investigation on the effects of load combination methods on fatigue lives of mooring chain links predicted by the FM based mooring fatigue assessment approach.

Chapter 7 draws conclusions and makes recommendations for future work.

Chapter 2. Literature Review

2.1 Introduction

In this chapter, a literature review is conducted in the relevant fields of offshore mooring systems including mooring fatigue analysis for common mooring lines (Section 2.2), mooring fatigue analysis for mooring chain links subjected to OPB (Section 2.3), mooring chain links subjected to torque (Section 2.4), mooring chain links tensioned over a curved surface (Section 2.5), and different load combination methods considered in mooring fatigue analysis (Section 2.6).

2.2 Mooring fatigue analysis for common mooring lines

2.2.1 Development of T-N/S-N curves for offshore mooring systems

The early attempt to understand the fatigue behaviour of mooring chains was made by de Laval (1971), who conducted a series of fatigue tests on 2 inch stud mooring chain links at six different loads, then plotted the T-N curves of the tested mooring chain links. Van Helvoirt (1982) performed experimental studies to investigate the static strength and the fatigue strength of 3-inch stud link chain links and of three types of 3-inch connecting links (Kenter, Baldt, and D shackle) in high-cycle fatigue range in an artificial sea-water environment. The ratios of the fatigue lives of connecting links to the stud link chain link are given.

Based on the results from a four-year DNV project entitled “Anchor Chain Vables Offshore-Material Properties-Reliability” on mooring lines, T-N curves for mooring chain links were summarized by Lereim (1985). Asano et al. (1986) presented the results of fatigue tests of 40 and 44 mm mooring chain links in air and water with and without cathodic protection. Fatigue test data for K3, K4, and K5 mooring chain links with diameters varied from 54-100 mm was provided, and the fatigue design curve derived was given by Bolt (1995).

Lucht et al. (1977) presented results of axial tension fatigue tests for 5/6 inch and 1.5 inch wire ropes. Hanzawa et al. (1981) plotted fatigue data for 50 mm diameter six-strand ropes, Multi-Strand ropes and Locked - Coil ropes. Thorpe et al. (1983) presented fatigue data of 40 mm wire ropes in air and seawater. Banfield et al. (2000) showed results of fatigue tests for fibre rope.

A series of experiments for the mooring lines of offshore floating structures were launched by API RP 2F1 (1993), and the T-N curves for common mooring chain links and wire ropes were released. API RP 2SK (1995) published the 1st edition of station-keeping code for mooring systems containing a design curve for connecting links. API RP 2SM (2001) released the mean and design fatigue curves for polyester ropes. The fatigue design S-N curves for common chain links, wire ropes, and fiber ropes were released by DNV OS E301 (2001) codes. Afterwards, most of the mooring systems were designed according to industry standards.

Besides, it is worth mentioning that because of the continuous updating of fiber ropes, abundant work was done for the fatigue test of fiber ropes recently (Weller et al., 2017; Banfield and Ridge, 2017; Lian et al., 2017; Chevillotte et al., 2018; Humeau et al., 2018).

2.2.2 T-N/S-N curves based mooring fatigue analysis for mooring lines

Larsen and Mathisen (1996), Lassen and Syvertsen (1997) applied T-N curves to predict the fatigue damage of mooring lines. Horde and Moan (1997) carried out mooring fatigue analysis accounting for the combination of low-frequency and wave-frequency motions.

Gao and Moan (2006) and Gao and Moan (2007) performed a frequency-domain analysis for bimodal nonGaussian fatigue damage prediction of mooring lines based on a simplified mechanical model and S-N curves. Gao and Moan (2008) performed a frequency-domain analysis for mooring lines subjected triple Gaussian loading processes to include the effect of VIV, and they examined the fatigue lives of mooring lines based on S-N curves.

Olagnon and Guédé (2008) proposed approximate formulae for predicting mooring line fatigue damage with a combined spectrum of one or several narrow-band low-frequency loads and a higher frequency load based on S-N curves. Trarieux and Lyons (2006) and Trarieux et al. (2008) proposed a method to consider VIV induced mooring line tension in the mooring fatigue analysis based on S-N curves.

Huang and Pan (2010) evaluated mooring fatigue damage based on S-N curves for single point mooring system of a cage. Qiao et al. (2010) compared the fatigue life of wire rope and fibre rope examined by T-N curves. Han et al. (2010) compared the fatigue life of the mooring system with 16 mooring lines (four by four) and 12 mooring lines (four by three) mooring system for an FPSO installed in the Gulf of Mexico based on S-N curves.

Huang et al. (2011) investigated the effects of pre-tension, dynamic stiffness, and T-N curves from different design codes on the predicted fatigue damage of taut-wire mooring system. Low and Cheung (2012) studied the effects of the strategy to lumping sea states into blocks on the fatigue lives of mooring lines based on S-N curves.

Bastid and Smith (2013) investigated the effects of residual stresses induced by proof loading test on the fatigue life of mooring chain links by FE analysis. Martinez Perez et al. (2017) extended the work of Bastid and Smith (2013), in which heat treatment is considered in the fatigue analysis. Kim et al. (2014) presented the design procedure of mooring lines of a floating offshore wind turbine, in which the fatigue lives of designed mooring lines should be checked by S-N curves. Qiao et al. (2014) compared the fatigue lives of the chain-wire rope-chain and chain-fibre rope-chain mooring lines examined by T-N curves under corrosion environmental condition.

Thies et al. (2014) studied the effect of mean stresses, sea states and measurements on the fatigue life of mooring lines of floating marine energy converters based on S-N curves. Xu et al. (2014) and Hou et al. (2018) performed fatigue analysis for a net cage mooring system using both the spectrum analysis method and the rainflow counting method. Yang et al. (2014) and Yang et al. (2016) compared coupled and de-coupled simulation procedures for the S-N curves based mooring fatigue analysis of wave energy converter. As the extension of their previous work, Yang et al. (2017) studied the effects of biofouling on the fatigue lives for mooring lines of wave energy converter based on S-N curves and they found biofouling would decrease the fatigue life of mooring lines.

Wu et al. (2015) conducted mooring fatigue analyses for semi-submersibles using the frequency-domain analysis based on T-N curves where low-frequency and wave-frequency loading and their combination are considered. The effects of mooring patterns, connecting links, bottom chain friction, damping coefficients, bottom chain lengths, and water depths on the fatigue lives of mooring chain links were discussed.

Du et al. (2016) conducted a T-N curves based fatigue analysis for the mooring lines applied in a semi-submersible with particular focusing on the low-frequency fatigue damage. The effects of water depth, wave spectral parameters, and riser system on the LF mooring fatigue damage were discussed. Li et al. (2016) applied several types probability density functions, including Rayleigh, GEV, and Gamma distributions, to fit the amplitudes of the short-term and long-term mooring line tension processes, and performed T-N/S-N curves based mooring fatigue analysis with the spectrum method in frequency-domain.

Wu et al. (2017) performed the fatigue analysis of hinge joints at the upper part of the Soft Yoke single point Mooring System based on S-N curves for the hinge. Chang et al. (2017) proposed a parametric method based on nonlinear transformations and stochastic optimization to calculate the fatigue lives of mooring lines subjected to non-Gaussian bimodal tension loading processes by T-N curves.

Jim et al. (2018) compared the fatigue lives of mooring chain links in Spar calculated by direct simulation method and condensed bin method. Sedghi and Kimiaei (2018) studied the effects of dynamic characteristics including mooring configurations, pretensions, water depths on the fatigue lives of mooring chain links calculated based on T-N curves. Fujiwara (2018) estimated the fatigue lives of mooring lines of a semi-submersible subjected to VIM motions based on T-N curves. Høeg and Zhang (2018) investigated the influence of different mooring line models on the dynamic responses of spar-type floating offshore wind turbines. They compared the fatigue equivalent loads of mooring lines modelled with the linear spring model, the quasi-static model, and the lumped-mass model.

Cevasco et al. (2018) predicted the fatigue lives of mooring lines of floating offshore wind turbine calculated by S-N curves. In their study, the comparison between the floating vertical axis wind turbine employing a mooring quasi-static model, and a modified floating vertical axis wind turbine using the lumped mass mooring line model was made. Chen and Basu (2018) investigated the effects of current and wave-current interactions in fatigue analysis of floating offshore wind turbines. Li et al. (2018) examined the fatigue lives of mooring lines of the floating offshore wind turbine in the environmental conditions of the Jeju offshore area in Korea based on S-N curves. They compared the fatigue lives of mooring chain links calculated by various wide-band loading combination method.

Clark and Paredes (2019) performed coupled simulations of the floating offshore wind turbine and its mooring system subjected to waves, and they achieved the tension time-series at the fairlead. The fatigue damage of mooring lines at the fairleads was estimated based on S-N curves, and the effects of placing wave energy converter in front of the wind turbine on the fatigue life of mooring chain lines were qualified. Pillai et al. (2019) compared frequency-domain and time-domain fatigue analysis for mooring lines of floating offshore wind turbine based on S-N curves.

Huang et al. (2019) implemented T-N curves based fatigue analysis for a mixed catenary mooring system of the floating wave energy converter serviced in deep water condition. Pham et al. (2019) performed time-domain mooring fatigue analysis for mooring lines in a semi-

submersible type floating wind turbines based on T-N curves. A comparison of the fatigue life of chain-nylon-chain and chain-polyester-chain mooring systems was made.

2.2.3 Fracture mechanism (FM) based mooring fatigue analysis

The initial fracture usually exists at the offshore mooring chain links due to the processes during the manufacture and installation (welding, proof loading test, etc.)

Mathisen and Larsen (2004) applied the linear elastic fracture mechanics to predict the mooring chain fatigue life and initial cracks are assumed to grow from the surface of a chain link with a semi-elliptical shape. Lassen et al. (2005) conducted a series of experiments to investigate the crack growth behaviour of high strength mooring chain links in a corrosive environment and S-N curves based approaches and the linear elastic fracture mechanics analysis were performed to compare with experimental results. Lardier et al. (2008) performed both S-N curves and the linear fracture mechanics based fatigue analysis for mooring lines considering corrosion effects and correlation between chain links.

Palin-Luc et al. (2010) and Pérez-Mora et al. (2015) conducted several experiments on R5 grade steel to investigate the effect of corrosion on very high cycle fatigue strength. A fracture mechanics analysis in which the stress intensity factor is estimated with hemispherical surface defects combined Paris-Hertzberg-Mc Clintock crack growth rate model was performed to compare with experimental results.

Ibekwe et al. (2018) examined the remaining fatigue lives of degraded mooring chain links via fracture mechanics based approach coupled with nonlinear finite element analysis. Arredondo et al. (2018) carried out finite element analyses to obtain stress intensity factors (SIFs) of mooring chain links for different sizes, material grades, crack shapes, crack depths and crack locations with considering pitting or interlink wear. Then empirical equations were fitted to predict the SIFs of mooring chain links.

2.3 Mooring chain links subjected to Out-of-plane bending (OPB)

Failure mode due to Out-of-plane bending (OPB) is one of the important fatigue failure modes of mooring chain links. 3 of 29 mooring fatigue accidents reviewed by Fontaine et al. (2014) in Chapter 1 are induced by OPB.

BV (2014) provided a nonlinear beam model to estimate OPB induced mooring fatigue damage between common chain links. DNVGL (2015) pointed out that the effects of OPB on the mooring fatigue should be considered for chain links directly contacted with other objects, e.g. mooring chain links connecting to the chain wheel, chain links passing over the bending shoe, chain links constraint provided by the chain hawse or the chain stopper. API (2008) indicates that stress concentration factor (SCF) of mooring chain links directly contacted with other objects should be carefully evaluated by finite element (FE) analysis, especially for mooring system designed for permanent platforms.

Vargas et al. (2004) performed FE analyses of 5.25-inch mooring chain links laying on 7-pocket mooring chain wheels, in which the stress concentration factors of flat-link laying on the chain wheels are evaluated. Luo and Heyl (2017) conducted a non-linear finite element analysis (FEA) to examine OPB behaviours of 168mm R4S studless chain links mooring chain links laying on a 7-pocket mooring chain wheel at fairlead. They showed that the chain wheel would aggravate the fatigue damage of the mooring chain links due to the additional contact and friction between the chain links and mooring chain wheel.

Melis et al. (2005) conducted a series of experiments to measure OPB stresses acting on mooring chain links passing bending shoes, and they further proposed an empirical equation to consider OPB stress as a function of the chain diameter, mooring line tension, and interlink angle. An FE analysis was performed by Vargas and Jean (2005) for mooring chain links to compare with the experimental results of Melis et al. (2005) and their work showed that stresses in chain links due to OPB could be a significant source of fatigue damage. Rampi and Vargas (2006) measured OPB stress and fatigue lives of stud mooring chain links passing over curve chain hawses and straight chain hawses. A comparison between OPB stresses measured in the experiments and that calculated using the empirical equation provided by Melis et al. (2005) was made, and fatigue lives of stud mooring chain links obtained in the experiments were then compared with those predicted using an S-N curves based approach.

Ter Brake et al. (2007) suggested an S-N curves based approach for predicting fatigue lives of mooring chain links subjected to OPB, in which a series of extensive FE analyses were performed to approximate OPB stress as a function of the interlink angle, friction coefficient, mooring line tension and mooring chain diameter. Lassen et al. (2009) and Lassen et al. (2014) also predicted fatigue lives of mooring chain links using an S-N curves based approach, in which a series of experiments were conducted to establish an empirical equation for describing the relationship between OPB stresses, imposed angle amplitude and mooring line tension.

Rampi et al. (2016a), Rampi et al. (2016b) and Rampi et al. (2016) summarized the results achieved from the Joint Industry Project (JIP) from different aspects. Rampi et al. (2016a) focused on the quasi-static OPB stiffness measurement campaign, and Rampi et al. (2016b) introduced the full-scale fatigue tests on chains. Rampi et al. (2016) summarized the FE analysis of mooring chain links subjected to OPB and provided the validation of the OPB mechanism through correlation with the test program results on mooring chain links.

Choung and Han (2016) proposed a numerical approach to predict OPB/IPB induced stresses without using SCFs or interlink angles. Choung and Lee (2018) made a comparison of OPB/IPB estimated by the method provided by Choung and Han (2016) and BV (2014). Martinez Perez et al. (2017) predicted residual stress distribution induced by proof loading test and heat treating of mooring chain links subjected to OPB. The effect of the residual stress distribution on the fatigue damage was then discussed.

Kim et al. (2018) performed a fatigue analysis for mooring chain link considering the OPB/IPB of a spread moored FPSO, in which both the interlink stiffness and stress concentration factors were derived from nonlinear finite element analyses, and the fatigue lives of mooring chain links were examined by T-N curves based approach. Mamiya et al. (2019) investigated the fatigue behaviour of chains subjected to OPB. Eight tests on reduced-scale chain samples were conducted to study the effects of the stress range, the mean stress, and the interlink angle on the fatigue life.

As seen from the above literature review, the problem that mooring chain links subjected to OPB is an important problem, which has attracted amount of attention from the industry recently. However, there is still a lack of comprehensive guidance in industry design codes with respect to how to account for OPB effects.

2.4 Mooring chain links subjected to torque

Theoretically, an axial load applying at the mooring chain link does not generate chain twist. However, in the engineering practice, the chain twist exists, and it causes torque loads between chains (Ridge et al., 2011). Ridge et al. (2011) give reasons to explain the existence of chain twist:

- Mooring lines may consist of mooring chains and ropes. Ropes are prone to be twisted, then, the mooring chains closing to ropes would be turned by ropes.

- Mooring chains may be twisted due to ignored reasons at the design stage, such as installing and operating.

There is little work has been done for the effect of torque on fatigue life of mooring chain links. Hiroshima and Sawa (1995) considered the effect on the strength of twist in a chain that is subject to an impact load by both finite element and experimental methods. Chaplin et al. (2000) present a series of mooring chain link experiments, in which the torques induced by chain twist are considered. Hobbs and Ridge (2005) and Ridge et al. (2016) introduced a frictionless theory to predict the mooring chain torques induced by chain twist. Ridge and Hobbs (2005) also presented experimental results of mooring chain stress caused by torque. Ridge et al. (2011) explored the effect of initial twist on the fatigue life of studless chain by experiments and the results show that show that the effects of torque on the fatigue lives of mooring chain links can be observed, and in some cases, the fatigue lives of mooring chain links would drop due to chain twist.

Also, Ridge (2008) discussed the behaviour of helically spun wire ropes when subject to axial load. Ridge (2009) described the tension-torsion fatigue behaviour of six-strand wire ropes applied in the offshore mooring.

As seen in the above literature review, the problems of mooring chain links subjected to torque are not attracted much attention from the industry. However, this type of problem should be addressed carefully, especially for mooring chain links that cannot be inspected (API RP 2SK, 2008).

2.5 Mooring chain links tensioned over a curved surface

If mooring chain links are laying on the ungrooved curved surface, they would be subjected to torque force as well (OCMIF, 2013). Limited literature about the behaviour of mooring chain links tensioned over the ungrooved surface can be found in industry reports, e.g. Marsh and Thurston (1961) and Buckle (1974).

Both OCMIF (2013) and Buckle (1974) pointed out that mooring chain links tensioned over a curved surface would suffer from extra stress concentration, and this case should be treated carefully.

2.6 Load combination methods for offshore mooring fatigue assessment

Most frequency-domain fatigue analyses for offshore mooring systems subjected to Gaussian load processes were performed using the Palmgren-Miner's rule and T-N/S-N curves, and these practices have been widely accepted by offshore design codes, i.e. DNVGL OS E301(2015) and API RP 2SK (2008), where narrow-band and wide-band load combination methods are suggested for predicting the combined loads induced by LF and WF motions in mooring fatigue analysis for an offshore mooring system.

The narrow-band method (Bendat, 1958) was developed based on the work of Rice (1954), and it estimates fatigue damage correlating with the spectral density function of the load process. This method is generally conservative and may significantly overestimate the actual fatigue damage (API RP 2SK, 2008) when the Palmgren-Miner's rule and T-N/S-N curves are used to predict fatigue damage.

Early attempts to predict the fatigue damage induced by wide-band were made by Wirsching and Light (1980), in which a correction factor between narrow-band and wide-band fatigue damage according to the fatigue strength exponent of the S-N curve and irregularity factor of load process was suggested. Dirlik (1985) approximated the probability density function of the amplitude of a wide-band load process as the sum of an exponential distribution function and two Rayleigh distribution functions and a fitting formula for wide-band fatigue damage prediction was then proposed.

Lutes et al. (1984) and Larsen and Lutes (1991) applied the single-moment spectral method in fatigue analysis for a structure subjected to wide-band load processes and a comparison between this method and the method of Wirsching and Light (1980) was made. Zhao and Baker (1992) proposed a model for the probability distribution of the rainflow stress range based on a mixed-distribution Weibull model whose parameters can be evaluated from the irregularity factor and a bandwidth parameter. Tovo (2002), and Benasciutti and Tovo (2005) attempted to present fatigue damage by the weighted linear combination of the narrow-band fatigue damage and the range counting damage intensity. Benasciutti and Tovo (2006) compared the Wirsching-Light method, Dirlik method, and Zhao-Baker method with the method presented in the work of Benasciutti and Tovo (2005).

A particular case of wide-band spectrum is called dual narrow-band spectrum, and its spectral density function is the summation of two narrow-band frequency components. This type of spectrum is characterised by two well-defined loading frequencies, and it is a typical example of the load responses observed in offshore mooring systems. Jiao and Moan (1990), and Fu and

Cebon (2000) proposed approximate formulae to predict fatigue damage of structures subjected to a dual narrow-band spectrum. Benasciutti and Tovo (2007) compared the two formulae, and some modifications to Fu-Cebon method was suggested.

2.7 Summary

Within the above literature, the following summarizes are achieved:

- Most of the mooring line systems are designed according to industry standards, and considerable research work was conducted on the fatigue analysis of common mooring chain links using the T-N/ S-N curves based approaches.
- Compared with T-N/S-N curves based analysis, there is limited work based on fracture mechanics.
- The type of problem that mooring chain links subjected to OPB has attracted amount of attention from the industry recently. However, this type of the problem is not well addressed.
- Attention should be paid to the problems that mooring chain links subjected to torque mooring chain links tensioned over curved surface.

Chapter 3. Mooring System Tension Analysis

3.1 Introduction

The reasonable prediction of environmental loads, motions and responses of the floating structure is of great importance in offshore mooring fatigue analysis. In this chapter, the theories and methodologies to predict the mooring line tension of an offshore permanent mooring system are introduced. A case study of mooring system analysis for a four-column ring pontoon semi-submersible operated at the Gulf of Mexico is presented as well.

3.2 Mooring System Tension

A mooring system of an offshore structure is usually a set of mooring lines to securing the platform to a specific operating location. The function of the tension T of a mooring line can be written as:

$$T = T_M + T_D \tag{3.1}$$

where T_M is the mean tension, which in general consists of four components: the pretension, mean wind-induced tension, mean wave drift-induced tension, and current-induced tension. T_D is the dynamic tension which should be considered as the tension induced by the combined loading process of low-frequency (LF) and wave-frequency (WF) motions.

The theory and methodology to calculate LF and WF tensions are introduced in this section.

3.2.1 Quasi-static low-frequency (LF) tension along mooring lines

A quasi-static analysis method is used for evaluating the LF tension of a mooring system in which the low-frequency tension is taken into account by vessel offsetting induced by the second-order waves and wind dynamics. In this approach, dynamic effects associated with mass, damping and fluid acceleration on the mooring lines are neglected.

As shown in Figure 3.1, a 2D catenary multi-component mooring line with segment numberings on a vessel with slow motion is considered.

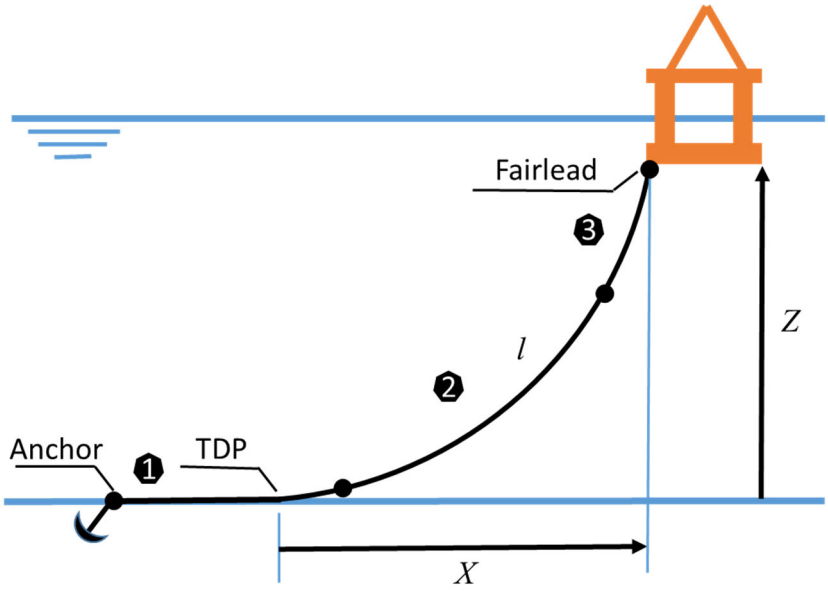


Figure 3.1: Geometry of a 2D catenary mooring line

The origin of the reference coordinate system (x, z) is located at the touchdown point (TDP). X is the horizontal distance from TDP to the fairlead, Z is the vertical distance from the seabed to the fairlead. The static equations for mooring system can be written as:

$$T_L = \sqrt{T_H^2 + (\sum w_i l_i)^2} \tag{3.2}$$

$$X = \sum x_i \tag{3.3}$$

$$Z = \sum z_i \tag{3.4}$$

where T_L is the mooring line tension at the fairlead induced by LF motion, T_H the horizontal tension force at fairlead, i the mooring component number, w_i the unit mooring line wet weight of each mooring component, l_i the suspended length of each mooring component. x_i and z_i denote the projected horizontal length and vertical depth of each suspended mooring component, respectively.

For the 3-component catenary mooring system shown in Figure 3.1, x_i and z_i can be given as:

$$x_1 = \frac{T_H}{w_1} sinh^{-1}\left(\frac{w_1 l_1}{T_H}\right) \tag{3.5}$$

$$z_1 = \frac{T_H}{w_1}\left[cosh\left(\frac{w_1 x_1}{T_H}\right) - 1\right] \tag{3.6}$$

$$x_2 = \frac{T_H}{w_2}\left[sinh^{-1}\left(\frac{w_2 l_2 + w_1 l_1}{T_H}\right) - sinh^{-1}\left(\frac{w_1 l_1}{T_H}\right)\right] \tag{3.7}$$

$$z_2 = \frac{T_H}{w_2}\left[cosh\left(\frac{w_2 x_2}{T_H} + sinh^{-1}\left(\frac{w_1 l_1}{T_H}\right)\right) - cosh\left(sinh^{-1}\left(\frac{w_1 l_1}{T_H}\right)\right)\right] \quad (3.8)$$

$$x_3 = \frac{T_H}{w_3}\left[sinh^{-1}\left(\frac{w_3 l_3 + w_2 l_2 + w_1 l_1}{T_H}\right) - sinh^{-1}\left(\frac{w_2 l_2 + w_1 l_1}{T_H}\right)\right] \quad (3.9)$$

$$z_3 = \frac{T_H}{w_3}\left[cosh\left(\frac{w_3 x_3}{T_H} + sinh^{-1}\left(\frac{w_2 l_2 + w_1 l_1}{T_H}\right)\right) - cosh\left(sinh^{-1}\left(\frac{w_2 l_2 + w_1 l_1}{T_H}\right)\right)\right] \quad (3.10)$$

For the 3-component taut mooring shown in Figure 3.2, the equation for x_i and z_i can be expressed as:

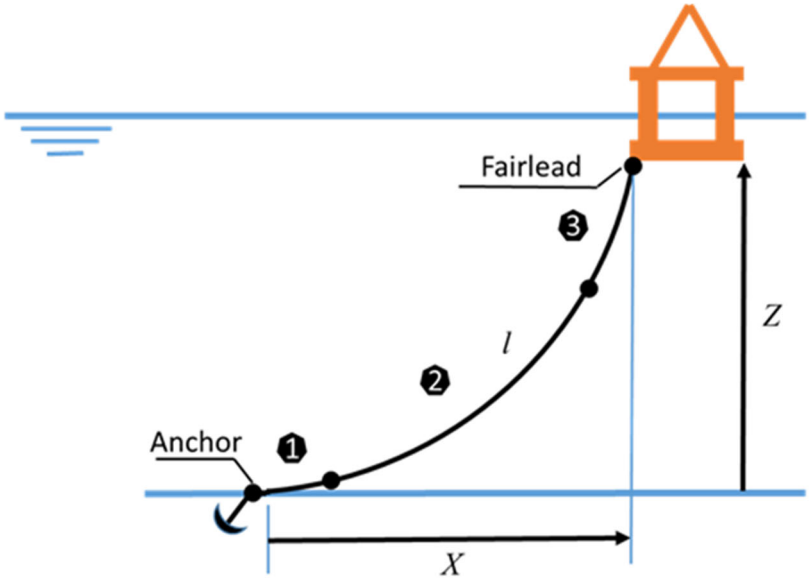


Figure 3.2 Geometry of a 2D taut mooring line

$$x_1 = \frac{T_H}{w_1}\left[sinh^{-1}\left(\frac{w_1 l_1}{T_H} + tan\theta_0\right) - sinh^{-1}(tan\theta_0)\right] \quad (3.11)$$

$$z_1 = \frac{T_H}{w_1}\left[cosh\left(\frac{w_1 x_1}{T_H} + sinh^{-1}(tan\theta_0)\right) - cosh(sinh^{-1}(tan\theta_0))\right] \quad (3.12)$$

$$x_2 = \frac{T_H}{w_2}\left[sinh^{-1}\left(\frac{w_2 l_2 + w_1 l_1}{T_H} + tan\theta_0\right) - sinh^{-1}\left(\frac{w_1 l_1}{T_H} + tan\theta_0\right)\right] \quad (3.13)$$

$$z_2 = \frac{T_H}{w_2}\left[cosh\left(\frac{w_2 x_2}{T_H} + sinh^{-1}\left(\frac{w_1 l_1}{T_H} + tan\theta_0\right)\right) - cosh\left(sinh^{-1}\left(\frac{w_1 l_1}{T_H} tan\theta_0\right)\right)\right] \quad (3.14)$$

$$x_3 = \frac{T_H}{w_3}\left[sinh^{-1}\left(\frac{w_3 l_3 + w_2 l_2 + w_1 l_1}{T_H} + tan\theta_0\right) - sinh^{-1}\left(\frac{w_2 l_2 + w_1 l_1}{T_H} + +tan\theta_0\right)\right] \quad (3.15)$$

$$z_3 = \frac{T_H}{w_3}\left[cosh\left(\frac{w_3 x_3}{T_H} + sinh^{-1}\left(\frac{w_2 l_2 + w_1 l_1}{T_H} + tan\theta_0\right)\right) - cosh\left(sinh^{-1}\left(\frac{w_2 l_2 + w_1 l_1}{T_H} + tan\theta_0\right)\right)\right] \quad (3.16)$$

where θ_0 is the mooring line angle from horizontal at the anchor point.

3.2.2 Damping along mooring line

The drag coefficients, both normal and tangential to a mooring line, are required when a dynamic analysis is carried out. Let $\Psi(l)$ be the displacement which is normal to the mooring line and $\Phi(l)$ the displacement along the mooring line. The normal and tangential damping forces are given as (Garza Rios et al., 1997):

$$F_\Psi = \frac{1}{2}\rho C_{dn} d_i \frac{\delta[\Psi(l)]}{\delta t}\left|\frac{\delta[\Psi(l)]}{\delta t}\right| \quad (3.17)$$

$$F_\Phi = \frac{1}{2}\rho C_{dl} d_i \frac{\delta[\Phi(l)]}{\delta t}\left|\frac{\delta[\Phi(l)]}{\delta t}\right| \quad (3.18)$$

where ρ is water density, and d_i is the diameter of each mooring component. C_{dn} and C_{dl} are drag coefficients in normal and longitudinal directions, respectively, and the values of . C_{dn} and C_{dl} can be referred to DVNGL OS E301 (2015).

For low-frequency slow-drift motion, F_Ψ and F_Φ can be expressed as (Garza Rios et al., 1997)

$$F_\Psi = \frac{1}{2w^2}\rho C_{dn} d_i (g_\Psi(\theta_F, \theta_i) \times |g_\Psi(\theta_F, \theta_i)|)\frac{\delta[\Psi(l)]}{\delta t}\left|\frac{\delta[\Psi(l)]}{\delta t}\right| \quad (3.19)$$

$$F_\Phi = \frac{1}{2w^2}\rho C_{dl} d_i (g_\Phi(\theta_F, \theta_i) \times |g_\Phi(\theta_F, \theta_i)|)\frac{\delta[\Phi(l)]}{\delta t}\left|\frac{\delta[\Phi(l)]}{\delta t}\right| \quad (3.20)$$

Where:

$$g_\Psi(\theta_F, \theta_i) = sin\theta_F tan\frac{\theta_i}{2} + 1 - cos\theta_i - sin\theta_i arsinh(tan\theta_i) \quad (3.21)$$

$$g_\Phi(\theta_F, \theta_i) = (1 - cos\theta_i)tan\frac{\theta_F}{2} - sin\theta_i + cos\theta_i arsinh(tan\theta_i) \quad (3.22)$$

where θ_F is the mooring line angle from horizontal at fairlead and θ_i the mooring line angle from horizontal of each suspended mooring component.

Considering the value of $g_\Psi(\theta_F, \theta_i)$ and $g_\Phi(\theta_F, \theta_i)$, it can be found that both normal and longitudinal damping are almost zero near touch down point (TDP) because θ_i is close to zero degrees. In addition, the maximum normal damping force occurs at the middle section of the suspended mooring line and longitudinal damping increases from the TDP towards the fairlead.

3.2.3 Dynamic analysis for wave-frequency (WF) tension

The variations in mooring tensions caused by wave-frequency motions are calculated by a dynamic method. In this analysis, the mooring line is modelled as a dynamic system (Barltrop, 1998):

$$M_M \frac{d^2r}{dt^2} + C_M \frac{dr}{dt} + K_M r = T_W \tag{3.23}$$

where, r is the displacement vector from mean position induced by WF motion of the platform. M_M, C_M and K_M are matrices of mass, damping and stiffness, respectively. T_W is the mooring line tensions excited by the first-order wave.

For the mooring analysis presented herein, WF motions of the platform and WF mooring line tensions are computed in the frequency domain using the wave spectrum and the response amplitude operators (RAOs).

3.2.4 Combination of low-frequency (LF) and Wave-frequency (WF) mooring line tension

As recommended by API RP 2SK (2008), the wave-frequency (WF) and low-frequency (LF) load processes are regarded as two independent narrow-banded random Gaussian processes and the combination of the two processes, namely the dynamic tension T_D, is considered for mooring fatigue analyses.

Both narrow-band and wide-band load combination methods are recommended for offshore mooring fatigue analysis by industry codes (DNV OS E301, 2015; API RP 2SK, 2008). The theory and methodology of different load combination methods and their effects on the predicted fatigue life of the mooring system are discussed in Chapter 6.

The narrow-band method is considered for predicting the fatigue life of the mooring system presented in Chapter 4 and Chapter 5. A brief introduce to show how to combine LF and WF mooring line tensions for fatigue analysis is presented herein.

In the narrow-band method, the standard deviation of the combined LF and WF tension process for each sea state, σ_{Ti} , is formulated as:

$$\sigma_{Ti} = \sqrt{\sigma_{Wi}^2 + \sigma_{Li}^2} \tag{3.24}$$

where σ_{Wi} and σ_{Li} are the standard deviations of the WF tension process and LF tension process for each sea state, respectively. The zero up-crossing frequency of the combined tension process for each sea state, v_{Ci}, can be given by:

$$v_{Ci} = \sqrt{\frac{\sigma_{Li}^2 v_{Li}^2 + \sigma_{Wi}^2 v_{Wi}^2}{\sigma_{Wi}^2 + \sigma_{Li}^2}} \tag{3.25}$$

where v_{Wi} and v_{Li} are the zero up-crossing frequencies of the WF and LF tension processes for each sea state, respectively.

3.3 Case study

3.3.1 A semi-submersible

A semi-submersible usually consists of a deck, several columns and pontoons. The semi-submersible obtains most of its buoyancy from submerged pontoons, and the deck is usually arranged high above the sea level. The first designed semi-submersible was Ocean Driller for drilling, which was launched in 1963 (Offshore Magazine, 1997). Then the advantages of the semi-submersible vessel stability were soon recognized by the offshore industry. Nowadays, a semi-submersible is in general designed for offshore drilling, oil production, heavy lifting, accommodation, or a combination of these functions.

A semi-submersible described in the work of Wu et al. (2015) is utilized in this thesis for case study. The selected semi-submersible comprises of a deck structure with four vertical columns connected to a ring pontoon, and the principal particulars of the selected semi-submersible are 96.0 m (Length) ×96.0 m (Width) × 53.0 m (Height). The platform structures under the main deck are symmetric in both east-west and south-north directions. The detailed principal dimensions of platform hull are listed in Table 3.1, and the geometry of the platform hull is shown in Figure 3.3.

Table 3.1: Principle dimensions of columns and pontoon of the semi-submersible

Length overall	96.0 m
Beam overall	96.0 m
Pontoon height	10.0 m
Pontoon width	22.0 m
Column corner radius	4.0 m
Height from baseline to deck bottom	53.0 m
Column width, longitudinal	22.0 m
Column width, transversal	22.0 m

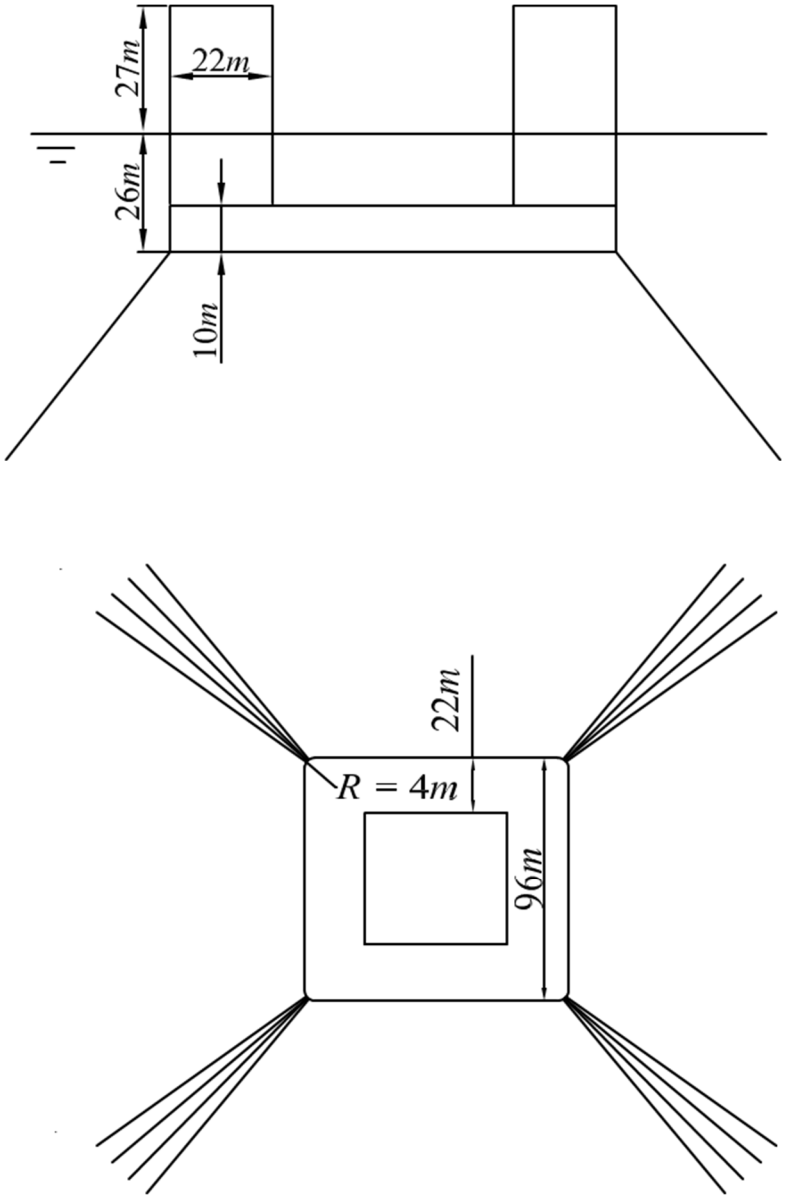


Figure 3.3: Geometry of the semi-submersible

3.3.2 Hydrodynamic analysis for the Semi-Submersible

The purpose of hydrodynamic analysis of the semi-submersible is to obtain the motion characteristics of the semi-submersible for the following mooring analysis.

For floating structures with large sizes, the wave radiation-diffraction approach should be applied to estimate the structure response. However, to include viscous effects in the analysis, a dual model frequency-domain analysis in Sesam Wadam, a frequency-domain hydrodynamic

program (DNVGL, 2019) , is carried out, in which case the buoyancy and added mass from the panel model are calculated based on the radiation-diffraction approach, and the drag force from the Morison model is predicted using Morison's equation.

As shown in Figure 3.4, the columns and pontoon are of the semi-submersible are modelled by both a Morison model and a panel model.

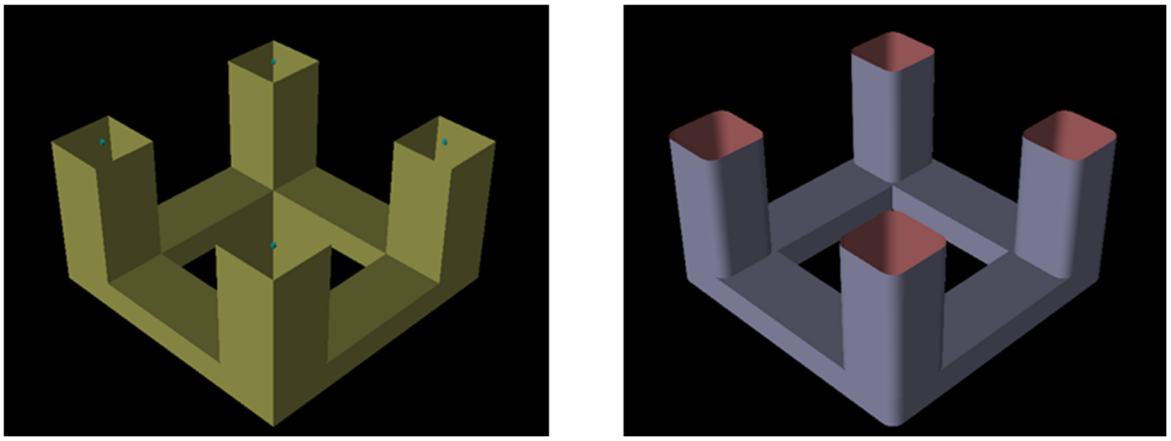


Figure 3.4: Morison model (Left) and panel model (right) of the semi-submersible

Then, the connections between the Morison model and the panel model is defined, and the hydrodynamic analysis is carried out, as shown in Figure 3.5.

After the hydrodynamic analysis, the added mass, RAOs considering damping effects, drift coefficients of the semi-submersible are achieved. Figure 3.6 plots the RAOs of the semi-submersible in six degrees of freedom.

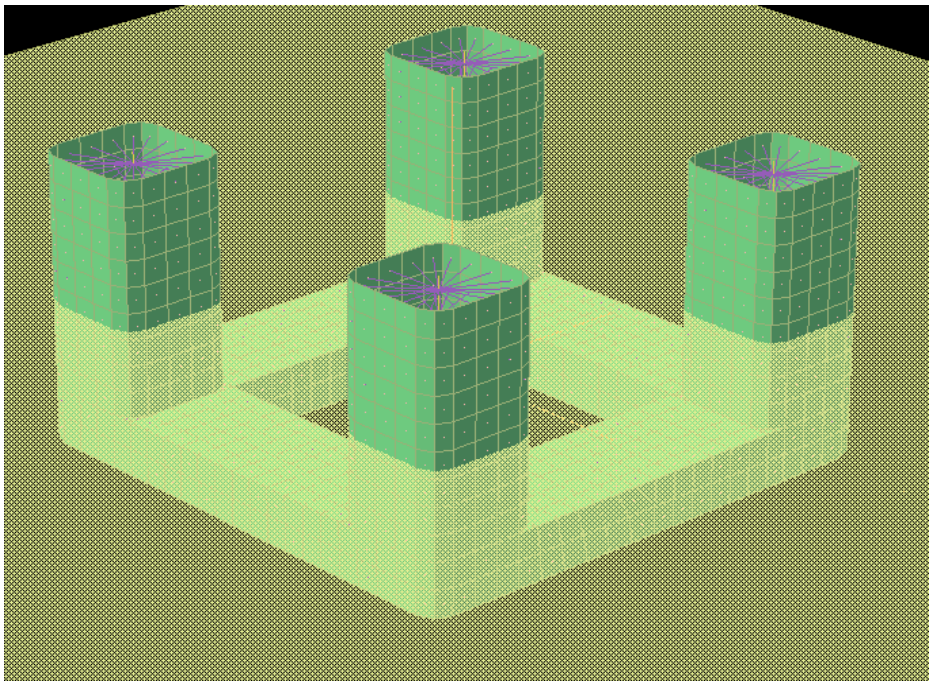


Figure 3.5: Dual model in hydrodynamic analysis

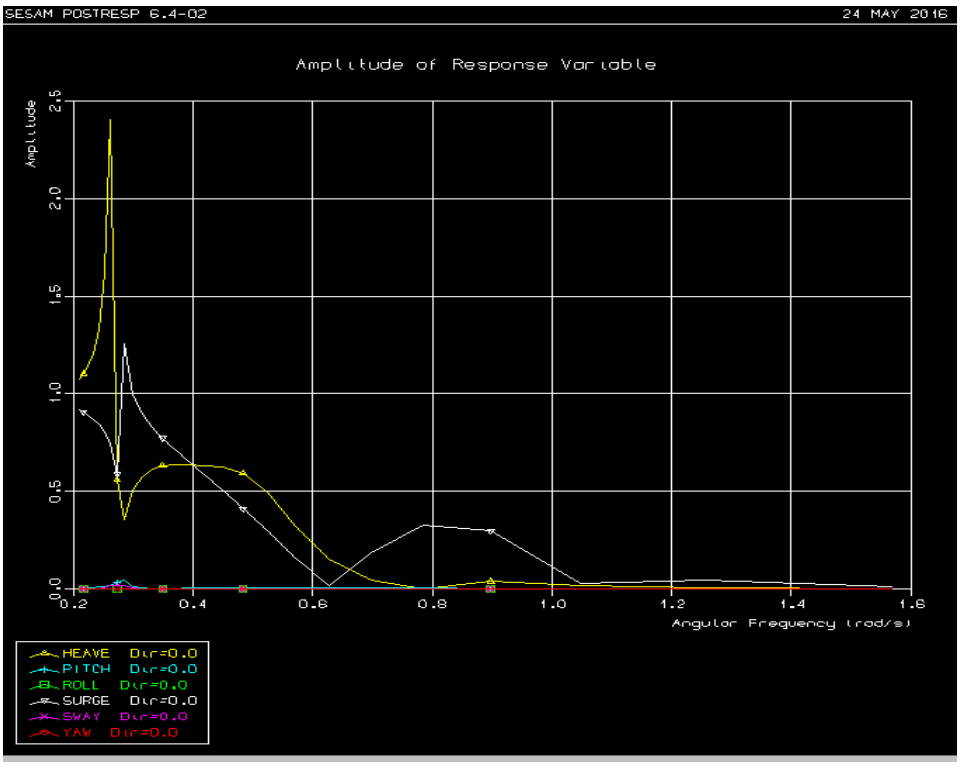


Figure 3.6 RAOs of the semi-submersible in six degrees of freedom

3.3.3 Description of designed mooring systems

Depending on the arrangement of mooring lines, mooring systems can be divided into a single-point mooring system and a spread mooring system.

In the single point mooring system, mooring lines are connected to the bow or midship of the floating structure. This design allows the floating structure to rotate around its bow or midship to minimize the effects of the direction of environmental loads. The single point mooring system is usually designed for ship-shaped vessels, e.g. an FPSO.

In the spread mooring system, multiple mooring lines are distributed around the floating structure by several groups, and the rotation of the floating structure is restricted compared with the single point mooring system. Generally, a spread mooring system is more economical than a single point mooring system, as there is no rotation equipment required in this design, e.g. turrets, yokes.

Compared to a ship-shaped vessel, the semi-submersible is relatively insensitive to the directions of wave, wind and current. Permanent spread mooring systems are designed to hold the semi-submersibles at the operating location.

Depending on the mooring configurations, mooring systems can be divided into catenary mooring systems and taut mooring systems, as shown in Figure 3.7.

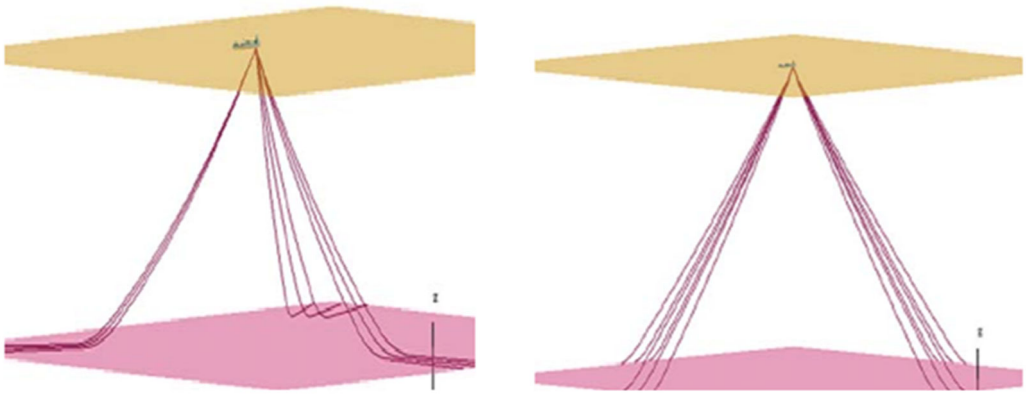


Figure 3.7: catenary mooring systems (left) and taut mooring systems (right)

The catenary mooring system is the most widely used system. In the catenary mooring system, part of the mooring line would lay on the seabed, when the platform is operated in the mean position.

In the taut mooring system, there is no line lying on the seabed in the static equilibrium position, when the platform is operated in the mean position. Compared with the catenary mooring system, the taut mooring system requires less mooring material. In addition, the taut mooring system is more suitable for deep or ultra-deep waters.

Four mooring systems (Cases A, B, C and D) are designed for this semi-submersible. In details, the semi-submersible is spread moored with 16 (4 × 4 groups) multi-material mooring lines emanating from four corner columns. The mooring system is symmetric in both east-west and south-north directions (Wu et al., 2015). Mooring line 1 is 37.5 degree clockwise from platform north and each two neighbouring mooring lines in the same cluster lay with 5-degree separation. The detailed layout of the mooring lines with numbering is shown in Figure 3.8.

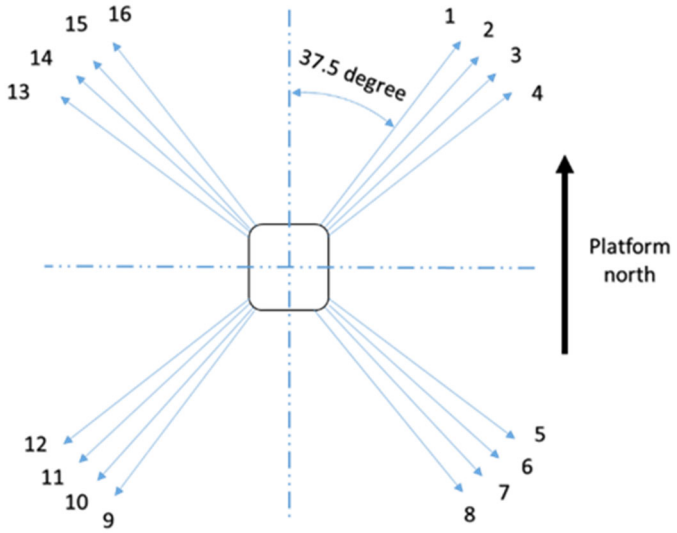


Figure 3.8: Detailed arrangement of 16 mooring lines serviced in the platform

Cases A and B are taut mooring systems. Cases C and D are catenary mooring systems. For each mooring system, the operating water depth is 1829 m (6000 ft), and the design life is 25 years. The connecting links jointing each mooring line segment are considered in Cases A and C but not accounted for in Cases B and D. The details of the four mooring systems are summarized in Table 3.2 (Wu et al., 2015).

Table 3.2: Designed mooring systems

Case	Mooring pattern	Pretension	Connecting links in the model?
A	Taut	3152 kN	Yes
B	Taut	3152 kN	No
C	Catenary	2102 kN	Yes
D	Catenary	2102 kN	No

Each mooring line consists of a 6-inch R4 grade studless bottom chain, a 267 mm polyester rope, and a 6-inch R4 grade studless top chain. The length of the bottom chain is 210 m and the top chain is 150 m long. The polyester ropes are 2600 m long with four segments. The wear and corrosion rate of mooring chain links is assumed to be 0.5 mm per year. The normal and longitudinal drag coefficients are set as (2.4, 1.15) for chains and (1.2, 0.1) for fibre ropes, respectively. The friction coefficient between the bottom line and seafloor is assumed to be 1.0 for catenary mooring systems (Wu et al., 2015). The connecting links jointing each mooring line segment are considered in Cases A and C but not accounted for in Cases B and D. The details of mooring material properties are summarized in Table 3.3.

Table 3.3: Mooring line characteristics

	Top chain	Polyester rope	Bottom chain
Axial stiffness (kN)	1.973×10^6	7.771×10^4	1.973×10^6
Mass per meter (t/m)	0.4598	0.05687	0.4598
Nominal diameter (m)	0.152	0.267	0.152
Equivalent diameter (m)	0.2736	0.230	0.2736
Minimum breaking load (kN)	17513	19424	17513

3.3.4 Environmental loads considered in the mooring fatigue assessment

The semi-submersible is assumed to be installed and operated at the central of the Gulf of Mexico, which is one of the most important deepwater offshore petroleum production regions in the world. Typical wave, wind and current conditions at the central of Gulf of Mexico have been simulated in the mooring analysis (API RP 2MET, 2014). The sea states of Gulf of Mexico considering wave, wind and current in collinear directions are listed in Table 3.4 (Wu et al., 2015).

3.3.4.1 Wave load

The wave-induced load acting on the semi-submersible are calculated in terms of response amplitude operators (RAOs) and long-term wave conditions. The Jonswap spectrum is used herein for the simulation of vessel motions induced by waves (MARINTEK, 2012):

$$S_J(\omega) = \alpha_J g^2 \omega^{-5} e^{\left[-\beta_J\left(\frac{\omega}{\omega_p}\right)^{-4}\right]} \gamma_J^{e^{\left[-\frac{(\omega-\omega_p)^2}{2\sigma_J^2\omega_p^2}\right]}} \tag{3.26}$$

where g is the acceleration of gravity, ω is the frequency in rad/s, $\omega_p$is the peak frequency in rad/s, γ_J is the peakedness parameter, α_J , β_J and σ_J are spectrum parameters given by (MARINTEK, 2012):

$$\alpha_J = \frac{(\frac{H_S\omega_p^2}{4g})^2}{0.065\gamma_J^{0.803}+0.135} \tag{3.27}$$

$$\beta_J = 1.25 \tag{3.28}$$

$$\sigma_J = \begin{cases} 0.07, \text{ for } \omega \leq \omega_p \\ 0.09, \text{ for } \omega > \omega_p \end{cases} \tag{3.29}$$

3.3.4.2 Wind load

The wind load F_W acting on the surface of the semi-submersible is calculated as MARINTEK, 2012):

$$F_W = \frac{1}{2} C_D \rho_a A_W V_W^2 \tag{3.30}$$

where C_D is the drag coefficient, ρ_a is the density of air, A_W is the project area of the surface perpendicular to wind, V_W is the wind speed, and it is considered as a statistical value that is generated herein from the Harris spectrum (MARINTEK, 2012):

$$S_W(f_W) = \frac{4kL_S U_{10}}{\left[2+\left(\frac{L_S f_W}{U_{10}}\right)\right]^{\frac{5}{6}}} \tag{3.31}$$

where k is the surface roughness coefficient, L_S is the scale length , f_W is the wind frequency, U_{10} is the mean wind speed at 10m above sea level

3.3.4.3 Current load

The current load F_C acting on the surface of the semi-submersible is given by MARINTEK, 2012):

$$F_C = \frac{1}{2} C_D \rho A_C V_C^2 \tag{3.32}$$

where C_D is the drag coefficient, ρ is the density of seawater, and A_C is project area of the surface perpendicular to current. The current speed V_C is considered as a constant value.

3.3.5 Results

LF and WF mooring line tensions of 16 moored mooring lines in all the sea states for the four designed mooring systems are listed in Appendixes and these values are used for the further mooring fatigue analysis. A comparison of between standard deviations of the combined LF and WF mooring line tensions achieved from this case study and data resource is made to validate the accuracy of the hydromantic analysis, and the results show that the maximum relative errors of standard deviations are less than 5%, which indicates that the results achieved from this case study are close enough to data resource.

RAOs of the tension and displacement of a mooring line in the direction of line tangent at its fairlead for the four designed mooring systems are shown Figures 3.9 and 3.10.

Table 3.4: Sea states of the central of Gulf of Mexico

Bin	Wave			Wind (m/s)	Current (m/s)	Collinear direction (clockwise, toward North)								Total (%)
	H_s	T_p	γ			0	45	90	135	180	225	270	315	
1	0.5	5	1	11	0.2	2.702	0.572	0.655	1.918	2.238	4.179	7.036	9.242	28.542
2	0.5	7	1	11	0.2	1.890	0.397	0.559	1.578	1.746	3.041	4.656	6.847	20.714
3	0.5	10	1	11	0.2	0.386	0.051	0.099	0.355	0.409	0.797	1.017	1.594	4.707
4	1.1	13	1	11	0.2	0.032	-	0.009	0.009	0.001	0.025	0.045	0.070	0.192
5	1.5	5	1	11	0.2	0.926	0.185	0.280	1.206	2.117	3.604	4.685	4.559	17.562
6	1.5	9	1	11	0.2	1.211	0.208	0.355	1.395	1.870	3.109	4.818	4.332	17.299
7	2.5	11	1	11	0.2	0.041	0.004	0.051	0.199	0.158	0.192	0.184	0.222	1.051
8	2.7	6	1	11	0.2	0.330	0.077	0.575	1.557	1.616	1.758	1.891	1.509	9.313
9	3.5	11	1	11	0.2	-	0.001	0.037	0.050	0.028	0.018	0.003	0.007	0.144
10	4.7	6	1	13	0.2	0.020	0.008	0.039	0.095	0.077	0.043	0.030	0.041	0.352
11	5.1	9	2	15	0.2	0.004	0.001	0.004	0.005	-	-	0.007	0.012	0.034
12	8.3	6	2	21	0.3	0.001	0.008	0.004	-	0.008	0.011	0.049	0.008	0.089
Total (%)						7.542	1.514	2.667	8.369	10.269	16.776	24.421	28.443	100

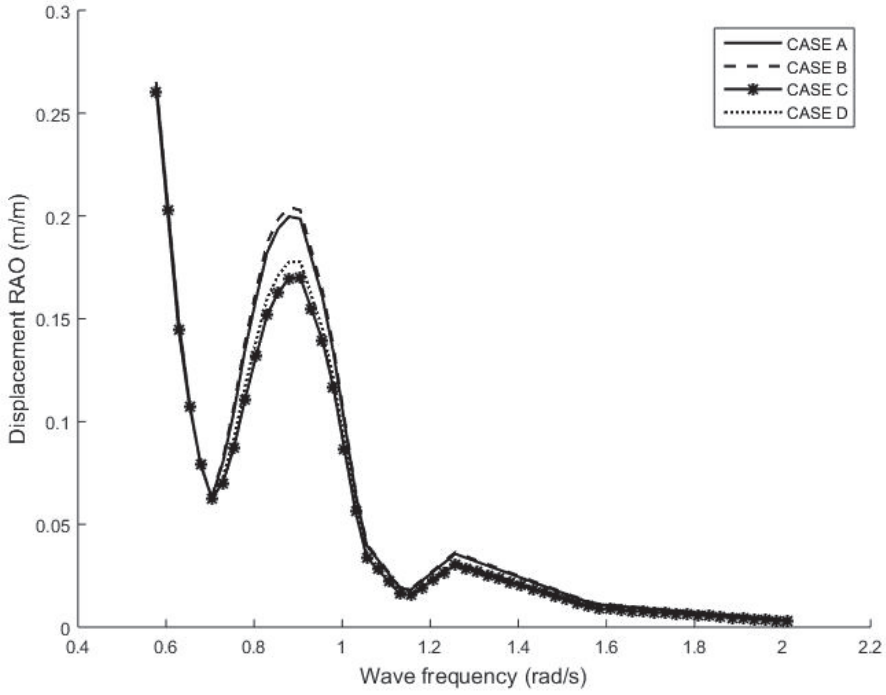


Figure 3.9 Displacement RAOs of mooring line in the direction consistent with the waves for each case

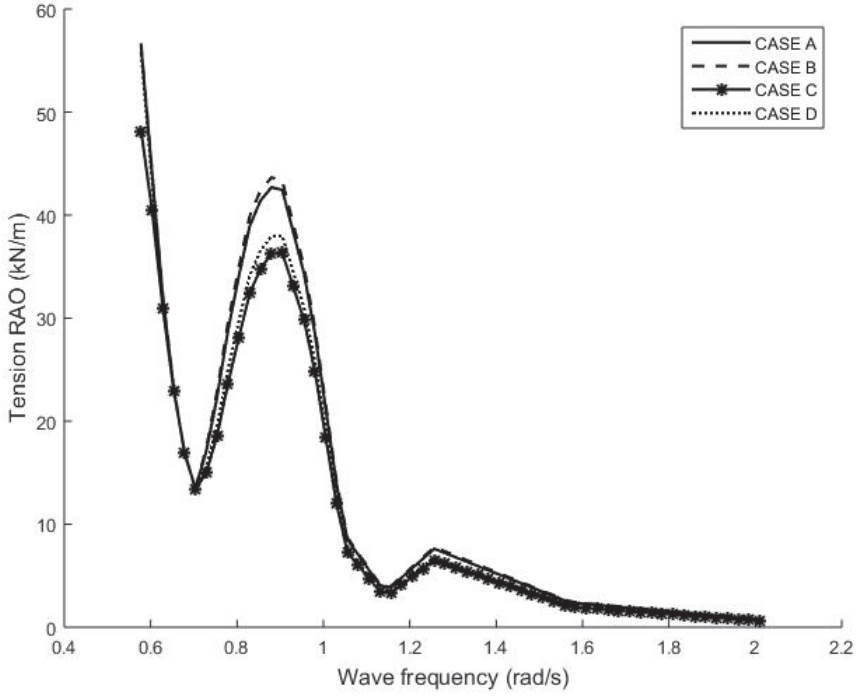


Figure 3.10 Tension RAOs of mooring line in the direction consistent with the waves for each case

Chapter 4. Fracture Mechanics (FM) based Fatigue Assessment for Mooring Lines Subjected to Pure Tension

4.1 Introduction

In this chapter, a fracture mechanics (FM) based mooring fatigue assessment approach is developed for offshore mooring systems. A comparison between T-N curves, S-N curves, and FM based mooring fatigue analyses for the semi-submersible selected for the case study in Chapter 3 is made. A parametric study to investigate the impact of initial crack shape, critical crack depth, and initial crack sizes on fatigue life of a mooring chain link is also conducted.

4.2 Palmgren-Miner's rule based fatigue analysis

As aforementioned, the fatigue life of a mooring system is traditionally predicted by the Palmgren-Miner's rule according to T-N or S-N curves and this kind of approach is generally well established and accepted by industry codes.

According to the Palmgren-Miner's rule, the accumulated damage of mooring lines, D, can be predicted by:

$$D = \sum D_i = \sum \frac{n_i}{N_i} \tag{4.1}$$

where D_i is the fatigue damage D for sea state i, and it can be considered as the ratio of n_i to N_i. n_i is the number of cycles of a tension range T_{Ri} or stress range S_{Ri} in the loading process and N_i is the number of cycles to failure under a constant tension range T_{Ri} or stress range S_{Ri}. In general, N_i can be determined from a design T-N or S-N curve corresponding to the tension range T_{Ri} or stress range S_{Ri}.

*4.2.1 **T-N curves based fatigue analysis***

As shown in Figure 4.1 (API RP 2SK, 2008), T-N curves for different mooring lines and connecting links are generally expressed as:

$$NR^M = K \tag{4.2}$$

where M is the slope of a T-N curve and K is the intercept parameter. R means the ratio of tension range, T_{Ri}, to reference breaking strength (RBS) of the mooring line. The reference values of M and K for different mooring lines and connecting links are listed in Table 4.1.

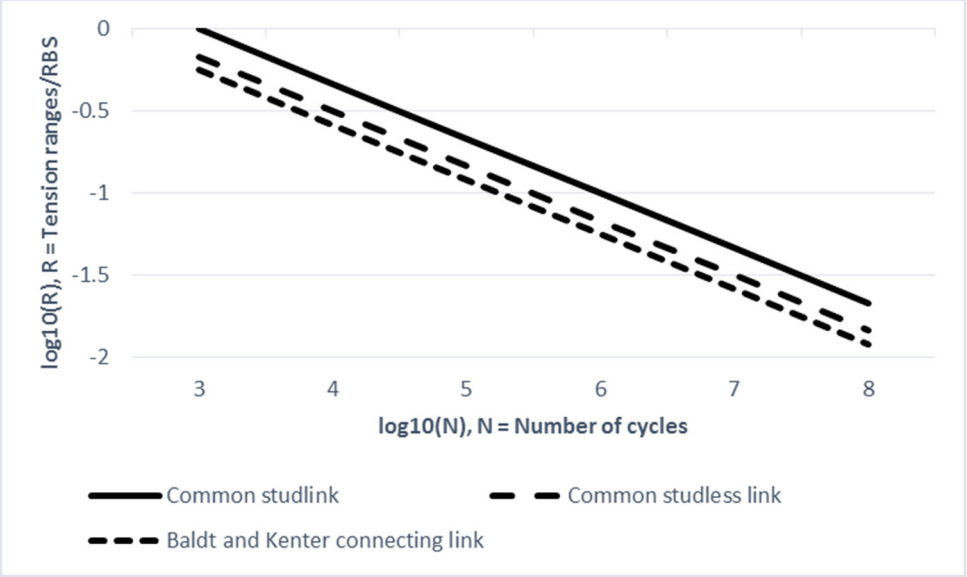


Figure 4.1: T-N curves for mooring lines and components (API RP 2SK, 2008)

Table 4.1: Parameters of M and K for mooring components (T-N curves) (API RP 2SK, 2008)

Mooring components	M	K
Common studlink	3.0	1000
Common studless link	3.0	316
Baldt and Kenter connecting link	3.0	178

If the RBS of a mooring chain link is not available, it may be approximated by API RP 2SK (2008):

$$RBS(kN) = 0.0211\, d^2(44 - 0.08\, d) \tag{4.3}$$

where d is the nominal diameter of a mooring chain link.

According to the Palmgren-Miner's rule, the mean value of the accumulated fatigue damage D for sea state i can then be derived as:

$$D_i = \frac{n_i}{K} E(R_i^M) \tag{4.4}$$

where $E(R_i^M)$ is the mean value of R_i^M, which can be expressed as (API RP 2SK, 2008):

$$E(R_i^M) = \int \left(\frac{T_{Ri}}{RBS}\right)^M f(T_R) d\, T_R \tag{4.5}$$

According to narrow-band assumption, the probability density function of the amplitude of narrow-banded tension process acting on mooring lines can be assumed to follow the Rayleigh distribution. In the mooring fatigue analysis, the tension ranges due to LF and WF motions can be considered as the double amplitude of tension process, and its probability density function also can be fitted to the Rayleigh distribution.

The expected fatigue damage D_i for sea state *i* taking into account the T-N curves thus can be reformulated as:

$$D_i = \frac{n_i}{K}\left(\sqrt{2}\sigma_{Ti}\right)^M \Gamma\left(1 + \frac{M}{2}\right) \tag{4.6}$$

where $\Gamma$is the gamma function, and $n_i$is the number of tension cycles encountered in sea state *i*. σ_{Ti} is the ratio of the standard deviation of the combined LF and WF tension range in sea state *i* to the RBS, $\Gamma$is the gamma function given as:

$$\Gamma(z) = \int_0^\infty x^{z-1} e^{-x} dx \tag{4.7}$$

4.2.2 S-N curves based fatigue analysis

For S-N curves based fatigue analysis, the same approach described in Section 4.2.1 can be applied and the tension range, T_R, is replaced by the nominal stress range, S_i. The fatigue damage can be calculated as (DNVGL OS E301, 2015):

$$D_i = \frac{n_i}{K}\left(\sqrt{2}\sigma_{Si}\right)^M \Gamma\left(1 + \frac{M}{2}\right) \tag{4.8}$$

where σ_{Si} is the standard deviation of the nominal stress ranges in sea state *i* . The nominal stresses in sea state *i,* σ_{ni}, can be calculated as:

$$\sigma_{ni} = \frac{T_{Ri}}{A} \tag{4.9}$$

where A is the area of cross-section. For chain links, A can be considered as $\frac{1}{2}\pi d^2$(DNVGL OS E301, 2015).

Reference values of M and K, and also typical S-N curves (DNVGL OS E301, 2015) for different mooring lines and connecting links are given in Figure 4.2 and Table 4.2.

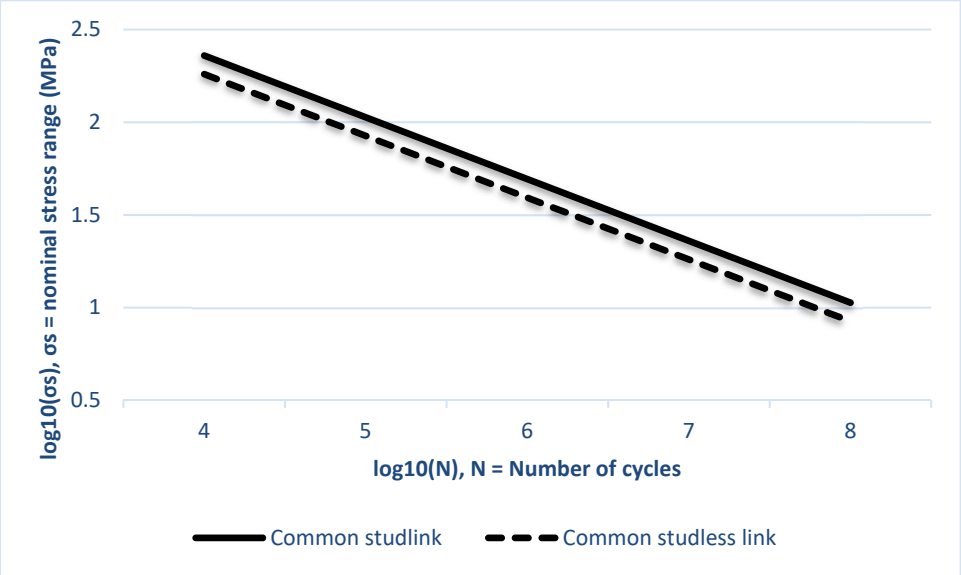


Figure 4.2: S-N curves for mooring lines and components (DNVGL OS E301, 2015)

Table 4.2: Parameters of M and K for mooring components (S-N curves) (DNVGL OS E301, 2015)

Mooring components	M	K
Common stud link	3.0	1.2×10^{11}
Common studless link	3.0	6.0×10^{10}

4.3 Fracture mechanics analysis

It is generally agreed with that the fracture mechanics based approach is more rational than T-N curves or S-N curves based approach for fatigue assessment. In the present paper, the chain links of mooring lines are modelled, and initial surface cracks are assumed to propagate at the surface of chain links. The stress intensity factor ranges are calculated based on mooring line tension ranges coupled with an FEM analysis.

4.3.1 Paris law and stress intensity factor

Fracture mechanics analysis for mooring chain links is performed herein based on the Paris-Erdogan equation (Paris and Erdogan, 1963) and BS7910 (2013). The chain link is treated as a round bar, and an initial surface crack is assumed to propagate at the surface of a chain link.

The crack growth is predicted using the Paris-Erdogan equation (Paris and Erdogan, 1963)

$$\frac{da}{dn} = C(\Delta K_a)^m$$

$$\frac{dc}{dn} = C(\Delta K_c)^m \tag{4.10}$$

where a is the crack depth, c the half crack length, n the number of stress cycles. C and m are material constants. The simplified crack growth model for steels in marine environments without protection suggested by BS7910 (2013) is used in this thesis, in which for steels in the marine enviroment without protection, $C = 2.3 \times 10^{-12}$, $m = 3$ (BS7910, 2013).

ΔK_a and ΔK_c are the stress intensity factor ranges, and the stress intensity factor K_{IC} is defined as (BS7910, 2013):

$$K_{IC} = Y\sigma\sqrt{\pi a} \tag{4.11}$$

where Y is the stress intensity correction factor, and $Y\sigma$ is calculated as:

$$Y\sigma = Mf_w(M_m k_{tm} M_{km}\sigma_m + M_b k_{tb} M_{kb}\sigma_b) \tag{4.12}$$

where k_{tm} and k_{tb} are stress concentration factors due to structural discontinuities.

For a semi-elliptical surface crack in a round bar as shown in Figure 4.3, $M = f_w = M_{km} = M_{kb} = 1$, M_m and M_b are given in Tables 4.3-4.6.

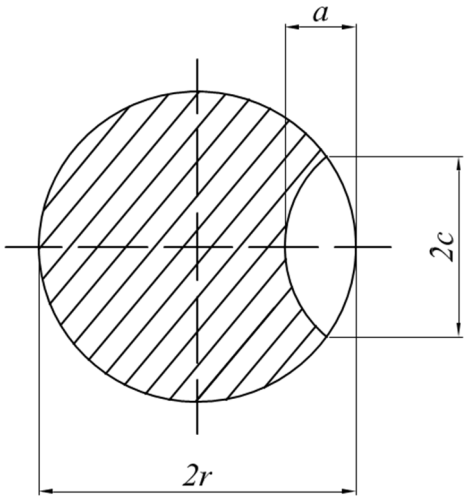


Figure 4.3: Geometry of a round bar with a semi-elliptical crack (a/r≪1)

Table 4.3: Stress intensity magnification factors $M_m$at the deepest point (a) of a semi-elliptical surface crack in a round bar (BS7910, 2013)

	a/c			
a/r	0.2	0.4	0.6	1
0.1	0.52	0.594	0.637	0.646
0.2	0.599	0.634	0.668	0.674
0.4	0.76	0.755	0.751	0.723
0.6	0.993	0.959	0.913	0.809
0.8	1.357	1.288	1.191	0.952
1	1.97	1.855	1.639	1.213

Table 4.4: Stress intensity magnification factors M_m at surface(c) of a semi-elliptical surface crack in a round bar (BS7910, 2013)

	a/c			
a/r	0.2	0.4	0.6	1
0.1	0.114	0.315	0.525	0.717
0.2	0.2	0.353	0.565	0.792
0.4	0.358	0.498	0.649	0.88
0.6	0.587	0.685	0.84	1.067
0.8	0.946	1.040	1.116	1.387
1	1.525	1.646	1.648	1.982

Table 4.5: Stress intensity magnification factors $M_b$at the deepest point (a) of a semi-elliptical surface crack in a round bar (BS7910, 2013)

	a/c			
a/r	0.2	0.4	0.6	1
0.1	0.489	0.558	0.599	0.604
0.2	0.523	0.554	0.582	0.582
0.4	0.567	0.564	0.558	0.526
0.6	0.629	0.608	0.576	0.491
0.8	0.731	0.695	0.638	0.482
1	0.91	0.858	0.754	0.523

Table 4.6: Stress intensity magnification factors M_b at surface(c) of a semi-elliptical surface crack in a round bar (BS7910, 2013)

	a/c			
a/r	0.2	0.4	0.6	1
0.1	0.107	0.305	0.511	0.702
0.2	0.172	0.321	0.529	0.755
0.4	0.254	0.384	0.537	0.779
0.6	0.349	0.440	0.591	0.849
0.8	0.477	0.560	0.657	0.961
1	0.657	0.751	0.825	1.173

For a semi-circle surface crack in a round bar as shown in Figure 4.4, $M = f_w = M_{km} = M_{kb} = 1$, and $M_m$and M_b are given by

$$M_m = g\left\{0.752 + 2.02\left(\frac{a}{2r}\right) + 0.37\left[1 - sin\left(\frac{\pi a}{4r}\right)\right]^3\right\} \tag{4.13}$$

$$M_b = g\left\{0.923 + 0.199\left[1 - sin\left(\frac{\pi a}{4r}\right)\right]^4\right\} \tag{4.14}$$

where

$$g = \frac{\frac{1.84}{\pi}\left[tan\left(\frac{\pi a}{4r}\right)/\left(\frac{\pi a}{4r}\right)\right]^{0.5}}{cos\left(\frac{\pi a}{4r}\right)} \tag{4.15}$$

where r is as shown in Figure 4.4.

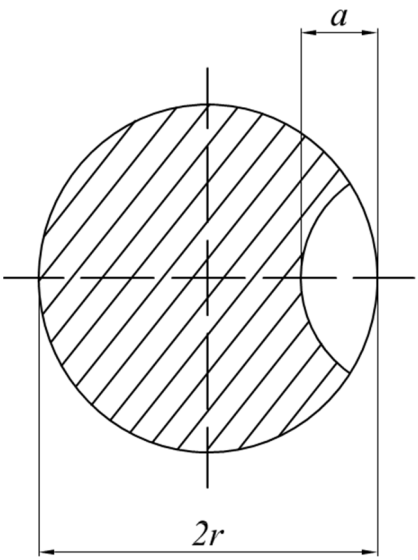


Figure 4.4: Geometry of a round bar with a surface semi-circle crack ($a/r \ll 1.2$)

σ_m and σ_b are membrane and bending stresses acting on two round bars induced by the combined wave and low-frequency tension. The fatigue life N is then estimated by an integration procedure

$$N = \int_{a_0}^{a_c} \frac{da}{C(\Delta K)^m} \tag{4.16}$$

where a_c is the critical crack depth and a_0 is the initial crack depth. As recommended by Mathisen and Larsen (2004), the critical crack depths are set as 12% of the chain diameter at weld sections, 30% of the chain diameter at bend section and 15% of the chain diameter at crown section. Since there is still no reliable data available on the initial crack depth of selected

mooring chain links, initial crack sizes of 0.5 mm suggested by ABS (2018) and Chen et al. (2011) are considered in the present paper.

4.3.2 Finite element analysis

A finite element (FE) analysis is performed to predict the tension-induced membrane and bending stresses acting on cross-sections of studless mooring chain links using ANSYS workbench (ANSYS. 2017).

4.3.2.1 Mooring chain model

R4 grade common studless mooring chain links are the main components of the top chains and bottom chains in designed mooring systems. For R4 grade chain material (DNVGL OS E302, 2015), the yield stress and tensile strength are as $580N/mm^2$ and 860 N/mm^2, respectively. A 3D finite element model for studless mooring chain links is built as shown in Figure 4.5 where the links are modelled with standard dimensions where the length L and breadth B are given by:

$$L = 6d,\ B = 3.35d \tag{4.17}$$

where d is the nominal diameter of the chain link. The corrosion allowance is also considered during the geometry of each link.

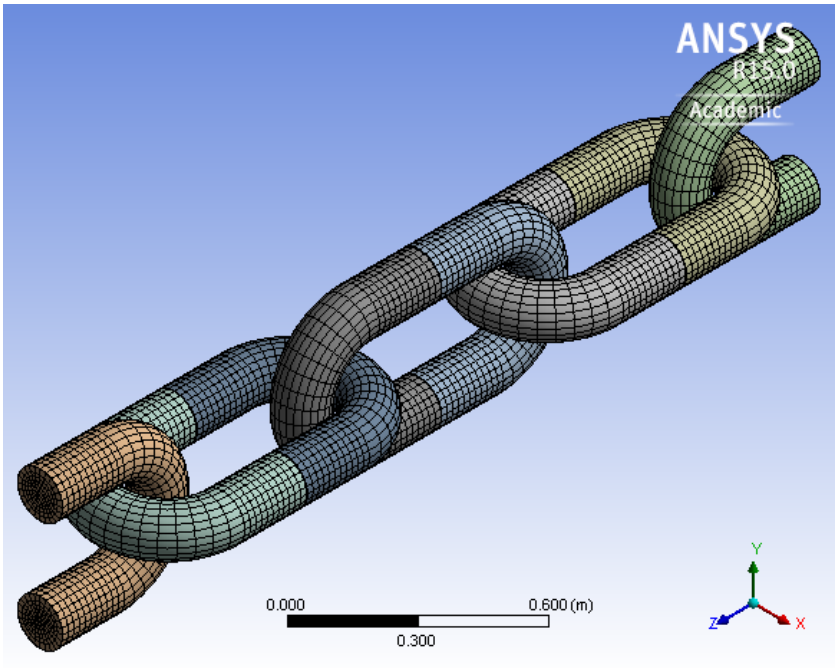


Figure 4.5: Finite element model of mooring chain links

The model is meshed with quadratic Hexahedron elements and the surface contract effects between two mooring chain links are considered, and the contact regions are meshed with quadratic quadrilateral contact/target elements as shown in Figure 4.6. The contact effects between mooring chain links and mooring equipment are considered, and the contact equation is given as:

$$F_{normal} = k_{normal} x_{penetration} \tag{4.18}$$

where F_{normal} is the contact force, k_{normal} is the contact stiffness, and $x_{penetration}$ is the penetration.

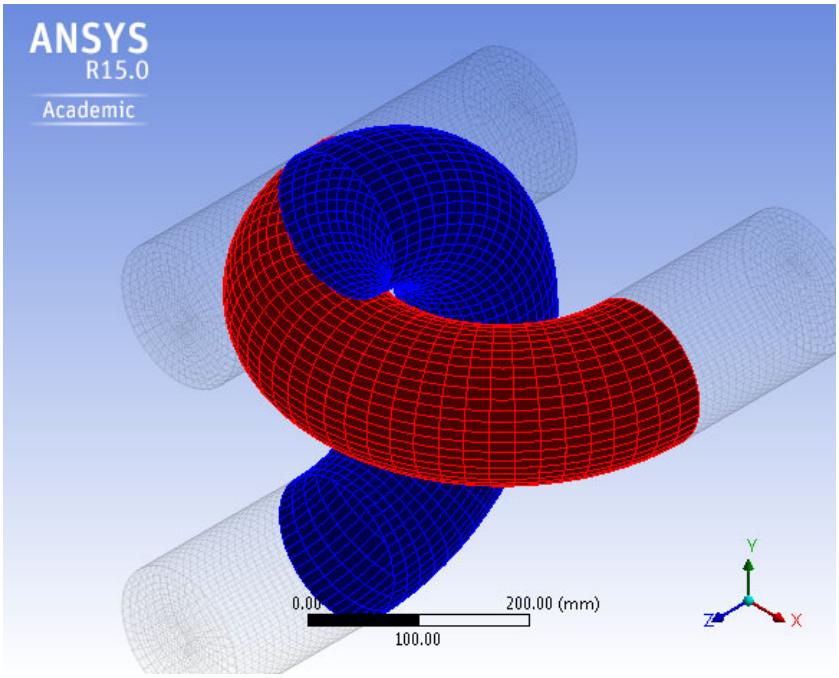


Figure 4.6: Meshed contact elements of mooring chain links

Two end faces in the same half mooring chain link are defined as symmetry planes. The tensile loadings are applied at the other two end faces along Z direction in Figure 4.5.

As suggested by Lassen et al. (2005) and Mathisen and Larsen (2004), the outside of crown cross-section, the inner surface of the beginning of the bend area (close to intrados where the chain shank and the crown intersect) and the inner surface of weld section, as shown in Figure 4.7, are treated herein as three potential locations that are prone to fatigue failure.

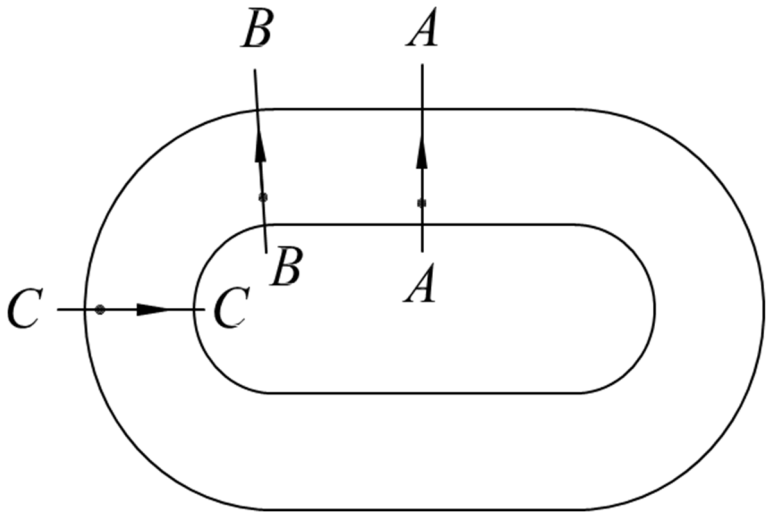
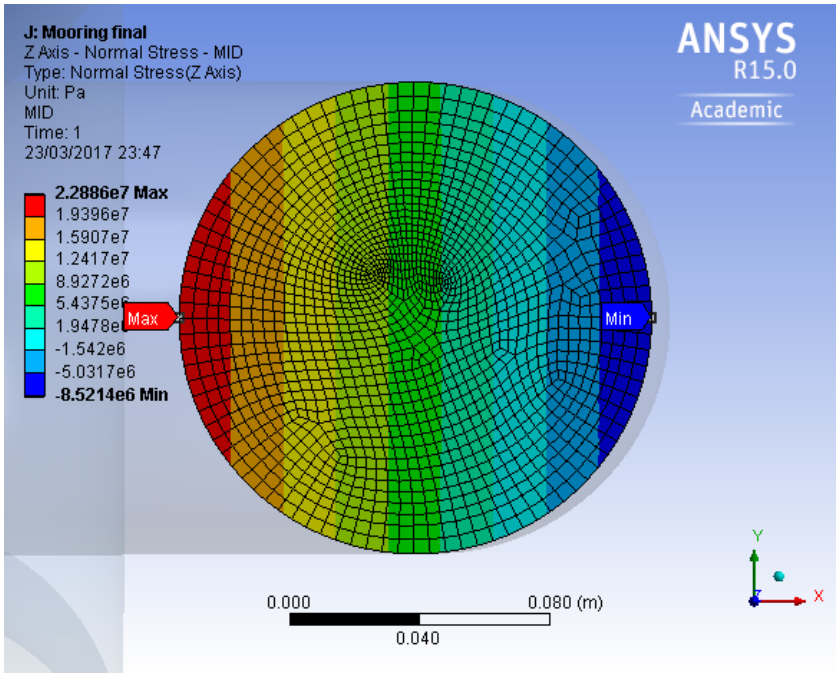
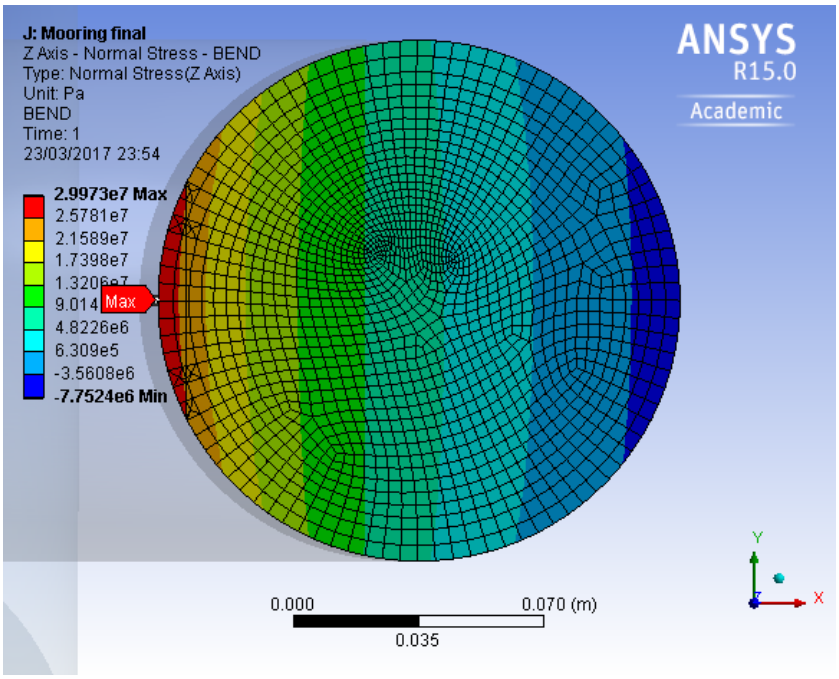


Figure 4.7: Locations of a chain link subjected to pure tension prone to fatigue damage

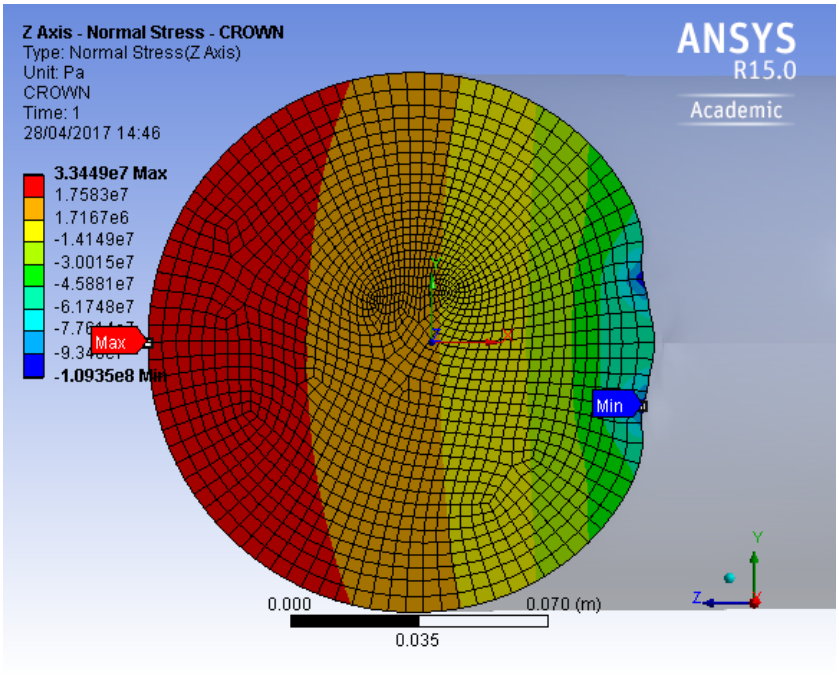
Figure 4.8 shows typical distributions of normal stresses (along the Z-axis of local coordinate as shown in Figure 4.7) of the weld, bend, and crown sections, respectively.



(a)



(b)



(c)

Figure 4.8: Normal stresses at locations of the chain link prone to potential fatigue damage: (a) weld section; (b) bend section; (c) crown section

4.3.2.2 Membrane and bending stresses

Membrane and bending stresses acting on the cross-sections of mooring chain links are calculated by linearizing the normal stresses of the cross-sections.

Membrane stress is the mean stress through the section thickness, which is given by:

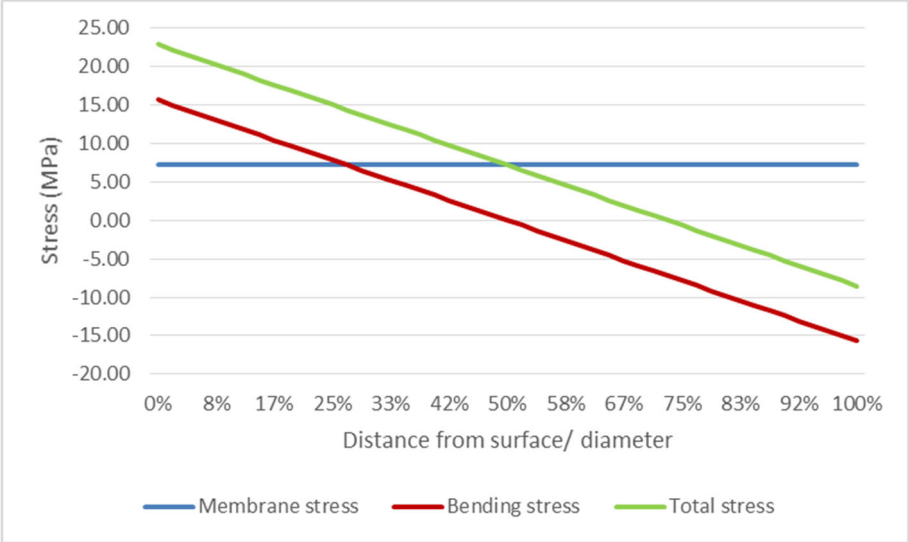
$$\sigma_m = \frac{1}{t}\int_0^t \sigma_{nor}(x)dx \tag{4.19}$$

where t is the total shell thickness, $\sigma_{nor}(x)$ the normal stress, x the local coordinate along the thickness direction as shown in Figure 4.8.

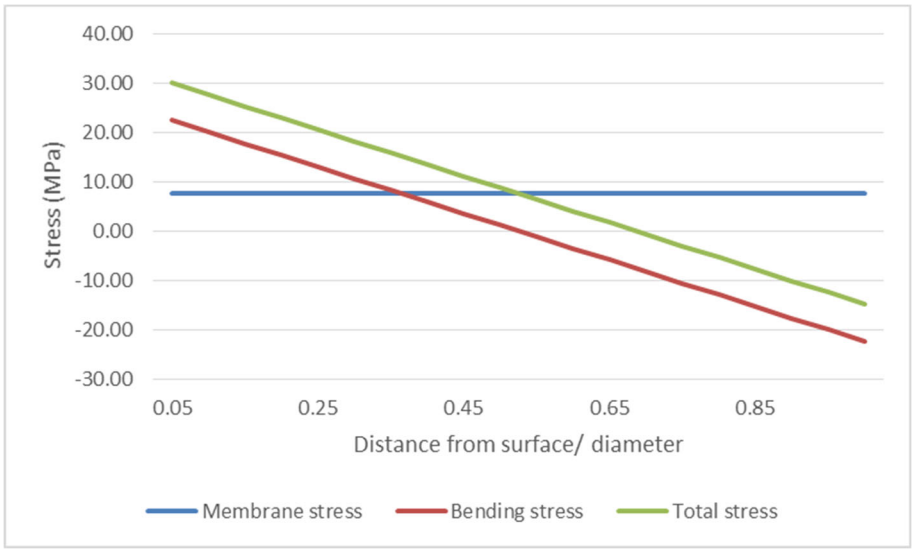
Bending stress is the component of stresses that varies linearly across the section thickness, and it can be calculated as:

$$\sigma_b = \frac{6}{t^2}\int_0^t \sigma_{nor}(x)(\frac{t}{2} - x)dx \tag{4.20}$$

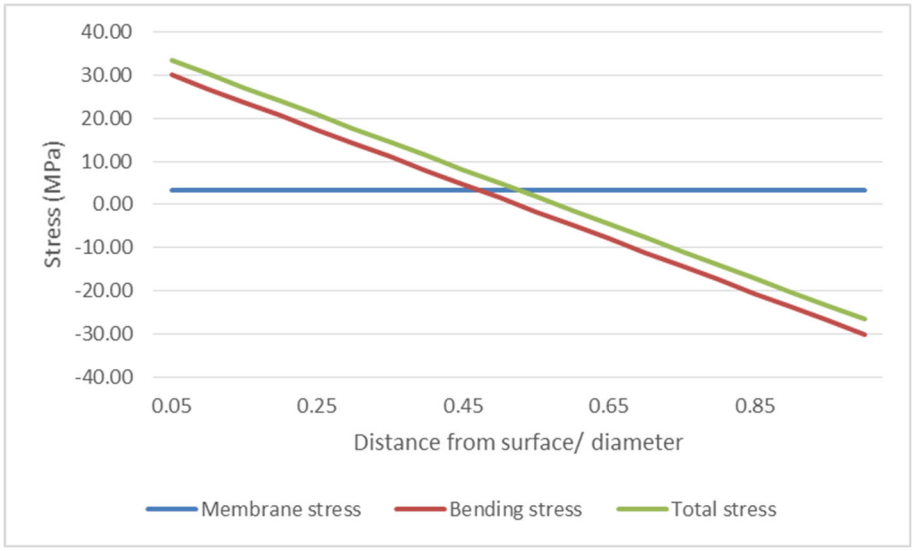
A linearization result of stress distribution over three cross-sections is plotted in Figure 4.9. As shown in Figure 4.9, the total normal stresses of the selected cross-section can be well fitted by the combination of membrane and bending stresses.



(a)



(b)



(c)

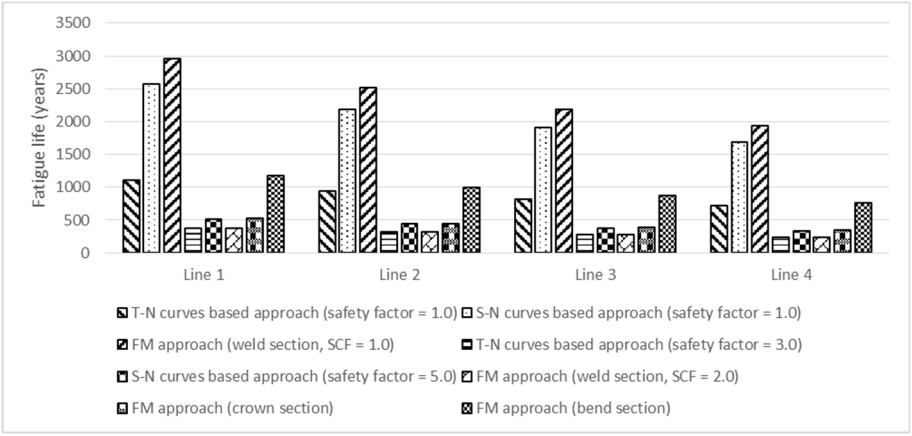
Figure 4.9: Linearization of stress distribution over a cross-section: (a) weld section; (b) bend section; (c) crown section

4.4 Comparison between T-N curves, S-N curves, and FM based fatigue analyses

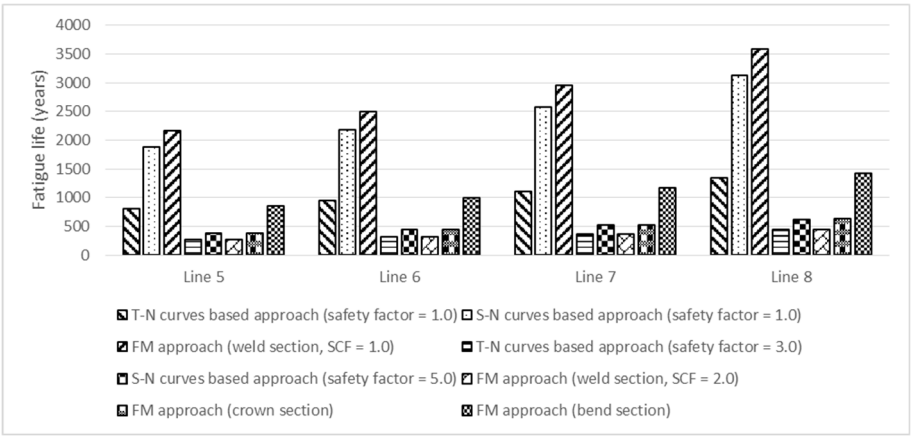
A comparison between T-N curves, S-N curves, and fracture mechanics based fatigue analyses is made in this section to validate the parameters considered in the FM based approach. The four mooring systems (Cases A, B, C and D in Chapter 3) designed for this semi-submersible, in which Cases A and B are taut mooring systems and Cases C and D are catenary mooring systems, are utilized for this comparison. Fatigue lives of mooring chain links calculated by the T-N and S-N curves based approaches with/without considering the safety factors suggested by

API RP 2SK (2008) and DNVGL OS E301 (2015) are plotted in Figures 4.10 to 4.13. Fatigue lives of weld section without/with considering a stress concentration factor (SCF), bend section, and crown section of mooring chain links predicted by the FM approach are also plotted in Figures 4.10 to 4.13.

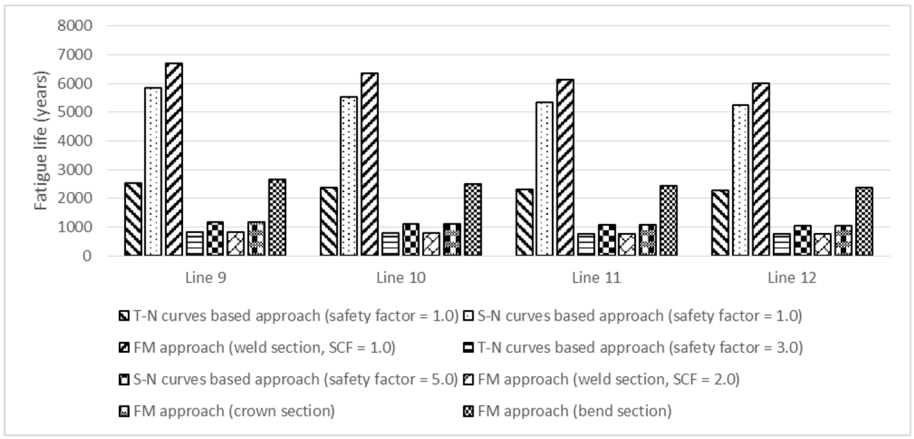
In the fracture mechanics analysis, the chain link is treated as a round bar, and a semi-elliptical shape surface crack with initial crack sizes of (0.5mm, 0.5mm) is assumed to propagate at the surface of a chain link with the simplified crack growth model. As recommended by Mathisen and Larsen (2004), the critical crack depths are set as 12% of the chain diameter at weld sections, 30% of the chain diameter at bend section and 15% of the chain diameter at crown section.



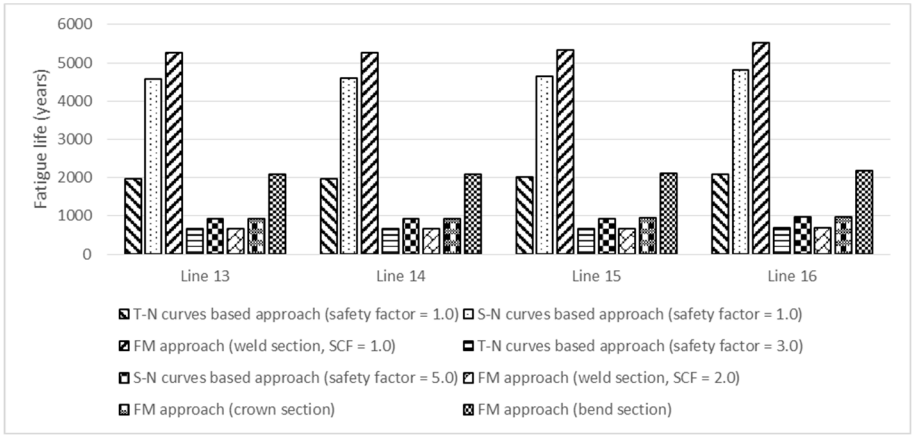
(a)



(b)

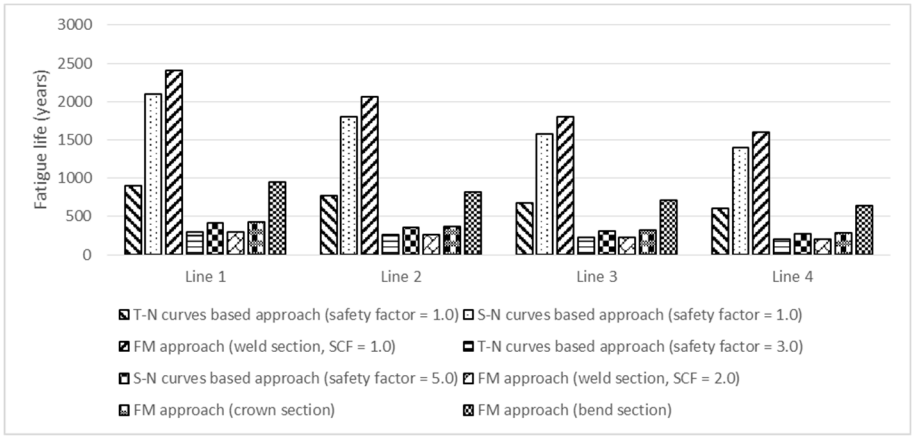


(c)

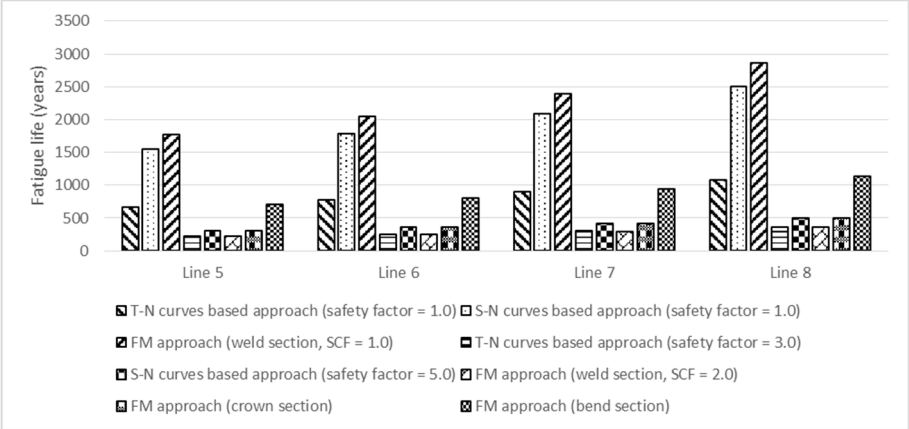


(d)

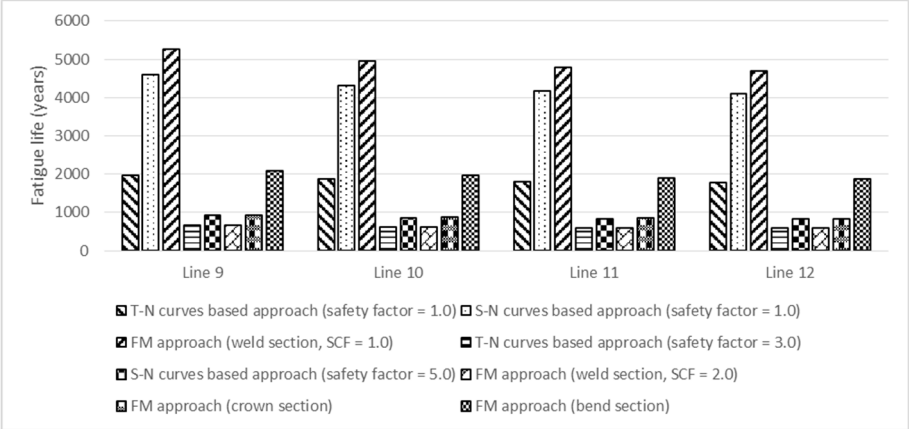
Figure 4.10: T-N curves, S-N curves, and fracture mechanics based fatigue analyses for mooring chain links subjected to the combined low-frequency and wave-frequency tension for Case A: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line 16



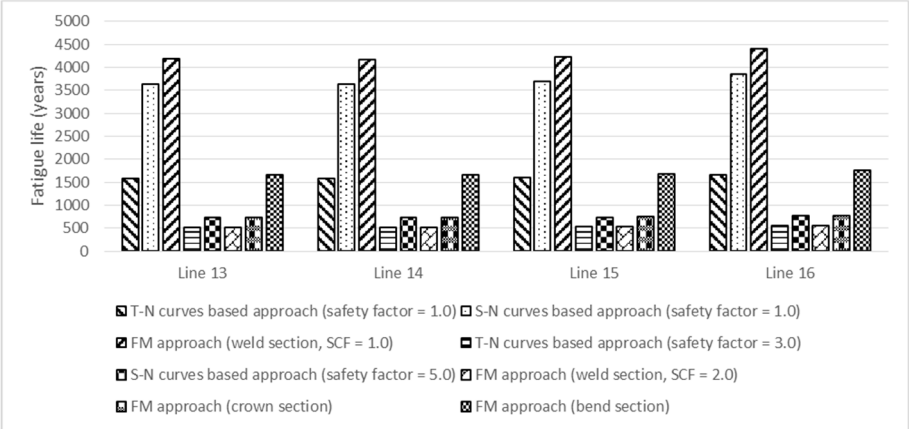
(a)



(b)

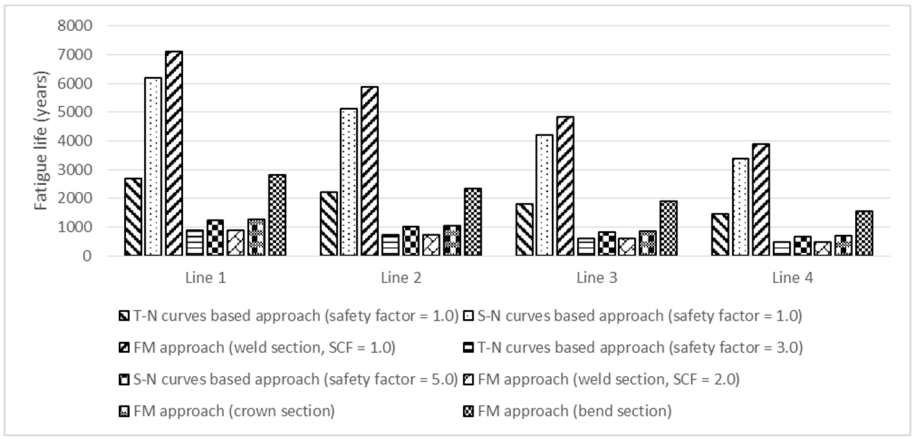


(c)

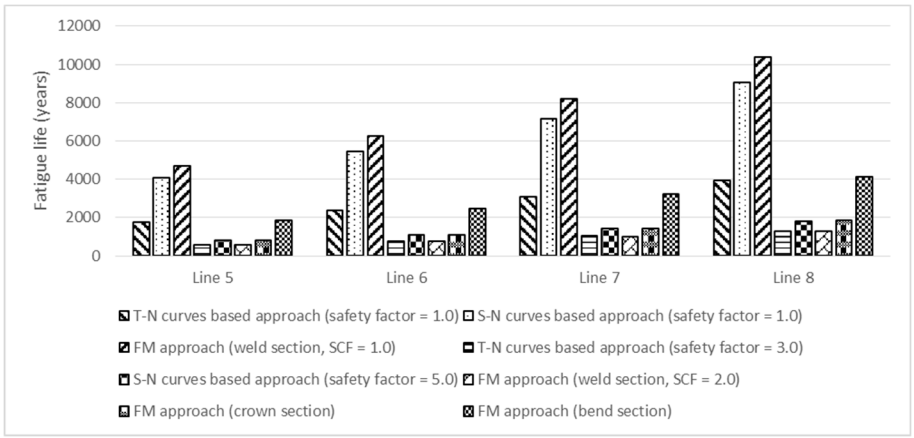


(d)

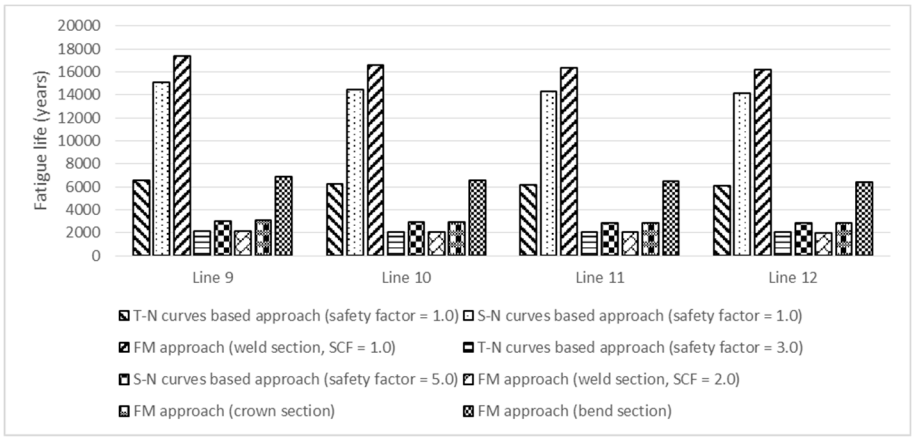
Figure 4.11: T-N curves, S-N curves, and fracture mechanics based fatigue analyses for mooring chain links subjected to the combined low-frequency and wave-frequency tension for Case B: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (c) Line 9 to Line 12; (d) Line 13 to Line 16


8000
7000
6000
5000
4000
3000
2000
1000
0
Fatigue life (years)
Line 1
Line 2
Line 3
Line 4
T-N curves based approach (safety factor = 1.0)
S-N curves based approach (safety factor = 1.0)
FM approach (weld section, SCF = 1.0)
T-N curves based approach (safety factor = 3.0)
S-N curves based approach (safety factor = 5.0)
FM approach (weld section, SCF = 2.0)
FM approach (crown section)
FM approach (bend section)

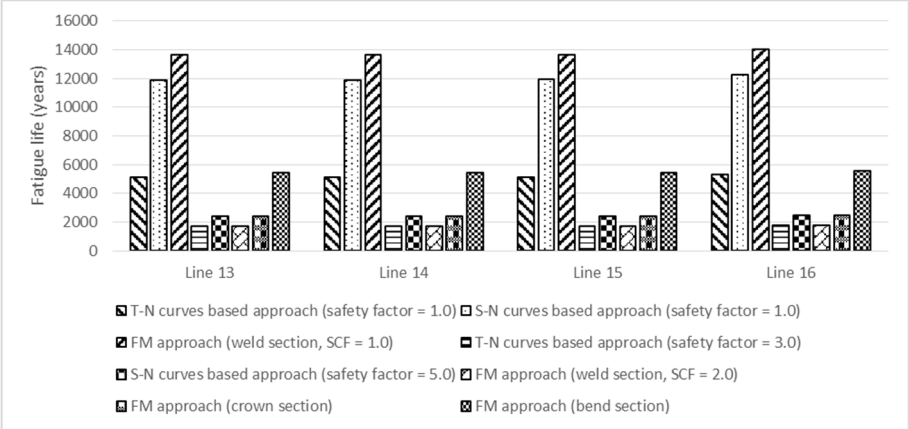
(a)


12000
10000
8000
6000
4000
2000
0
Fatigue life (years)
Line 5
Line 6
Line 7
Line 8
T-N curves based approach (safety factor = 1.0)
S-N curves based approach (safety factor = 1.0)
FM approach (weld section, SCF = 1.0)
T-N curves based approach (safety factor = 3.0)
S-N curves based approach (safety factor = 5.0)
FM approach (weld section, SCF = 2.0)
FM approach (crown section)
FM approach (bend section)

(b)

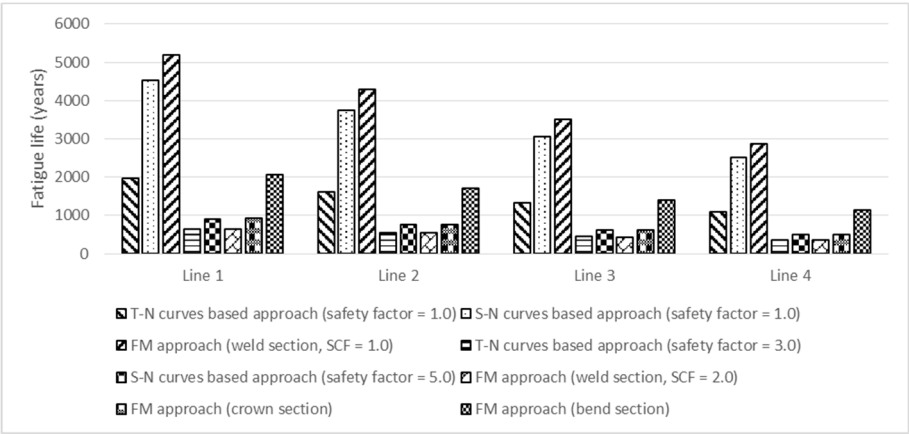

20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Fatigue life (years)
Line 9
Line 10
Line 11
Line 12
T-N curves based approach (safety factor = 1.0)
S-N curves based approach (safety factor = 1.0)
FM approach (weld section, SCF = 1.0)
T-N curves based approach (safety factor = 3.0)
S-N curves based approach (safety factor = 5.0)
FM approach (weld section, SCF = 2.0)
FM approach (crown section)
FM approach (bend section)

(c)

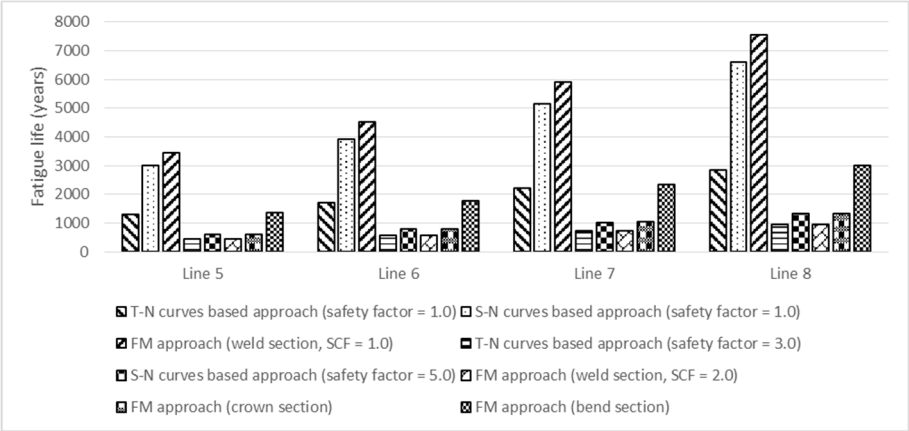


(d)

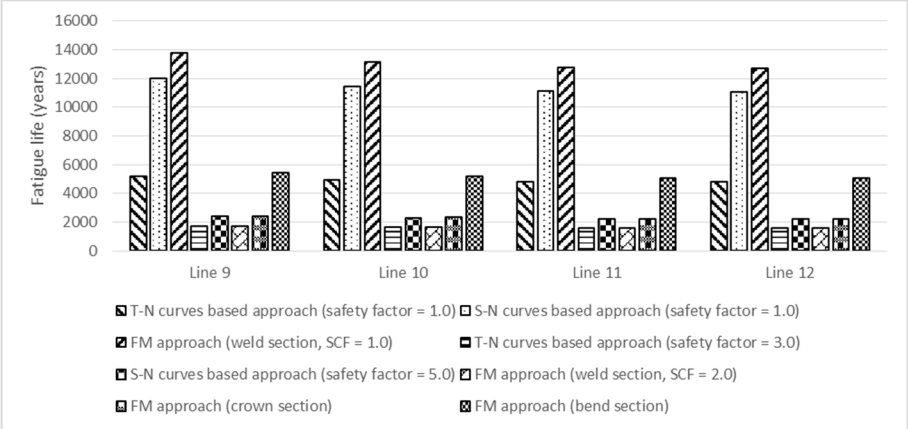
Figure 4.12: T-N curves, S-N curves, and fracture mechanics based fatigue analyses for mooring chain links subjected to the combined low-frequency and wave-frequency tension for Case C: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line 16



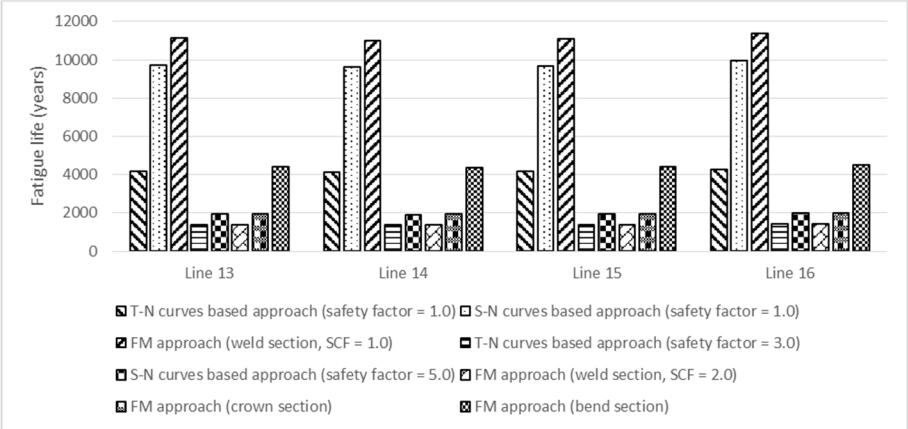
(a)



(b)



(c)



(d)

Figure 4.13: T-N curves, S-N curves, and fracture mechanics based fatigue analyses for mooring chain links subjected to the combined low-frequency and wave-frequency tension for Case D: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line 16

Figures 4.10-4.13 show that fatigue lives predicted by the T-N and S-N curves based approaches without considering safety factor are quite different and the fatigue lives predicted by the S-N curves based approach are about 130% longer than those calculated by the T-N curves based approach for all four cases. After applying the safety factor 3.0 suggested by the API RP 2SK (2008) for the T-N curves based approach and 5.0 suggested by the DNVGL OS E301 (2015) for the S-N curves based approach, Figures 4.10 to 4.13 show that the fatigue lives predicted by the S-N curves based approach are only about 39% longer than those calculated by the T-N curves based approach and the T-N curves based approach is only slightly conservative than the S-N curves based approach for fatigue life prediction of mooring chain links.

Regarding the fatigue life prediction using the fracture mechanics based approach, Figures 4.10 to 4.13 show that fatigue lives of weld section of a mooring chain link with an SCF of 2.0 are generally the shortest compared with those of bend and crown sections. Also, the predicted fatigue lives of weld sections are sensitive to the variation of SCF, which is often depending on the welding quality. As it can be seen from Figures 4.10 to 4.13, fatigue lives of mooring chain weld sections with an SCF of 2.0 are only 12.5% of the fatigue lives of mooring chain weld sections without considering a SCF. In addition, Figures 4.10 to 4.13 show that the crown sections of mooring chain links are prone to fatigue damage and the fatigue lives of crown sections are only 44% of those of bend sections and 18% of those of weld sections without considering an SCF.

Additionally, Figures 4.10 to 4.13 show that the fatigue lives predicted by T-N curves, S-N curves, and FM based approaches are in general comparable if the safety factors suggested by API and DNVGL are considered in the T-N and S-N curves based approaches. Fatigue lives of weld sections considering an SCF of 2.0 predicted by the FM approach are quite close to those calculated by the T-N curves based approach considering the safety factor 3.0 suggested by the API RP 2SK (2008). Fatigue lives of crown sections estimated by the FM approach are only 1% longer than those predicted by the S-N curves based approach considering the safety factor 5.0 suggested by the DNVGL OS E301 (2015).

Furthermore, Figures 4.10 to 4.13 show that for the four mooring systems, mooring lines 1 to 8 are prone to fatigue failure compared to mooring lines 9 to 16 and the mooring line 4 of each mooring system is the line with the shortest fatigue life. Moreover, Figures 4.10 to 4.13 show that the fatigue lives of the catenary mooring system (C and D Cases) are generally longer than those of taut mooring system (A and B Cases). Figures 4.10 to 4.13 also show that fatigue lives of Cases A and C are generally longer than those of Cases B and D, respectively. As mentioned in Chapter 3, the connecting links are considered in Cases A and C but not accounted for in Cases B and D. Therefore, it might be indicated that fatigue lives of mooring chain links will be underestimated if without taking into account the influence of connecting links.

4.5 Parametric study

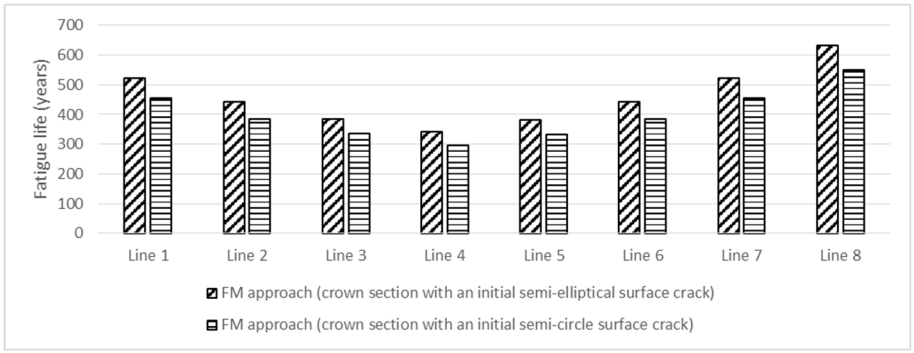
The fatigue damage predicted by the fracture mechanics based approach generally varies with the assumptions made in the fracture mechanics analysis, such as initial crack shapes, initial crack sizes and critical crack depths. In order to investigate the effects of these factors on the

fatigue lives of mooring chain links, a parametric study is carried out for the mooring system in Case A.

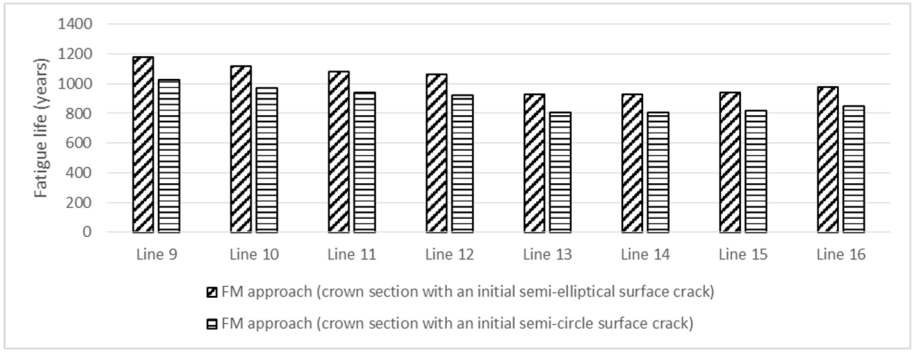
4.5.1 Effect of initial crack shapes

Two types of initial surface crack shapes are considered in the fracture mechanics analysis, namely semi-elliptical surface crack and semi-circle surface crack. The comparison of the fatigue lives of crown sections of mooring chain links predicted with the initial semi-elliptical surface cracks and the initial semi-circle surface cracks is carried out for the mooring system Case A and the results are plotted in Figure 4.14.

Figure 4.14 shows that the fatigue lives calculated with these two types of initial surface crack shapes share the same trends for each mooring system. The fatigue life of each mooring chain link in each case calculated with the initial semi-elliptical surface crack is 15% longer than that calculated with the initial semi-circle surface crack.



(a)



(b)

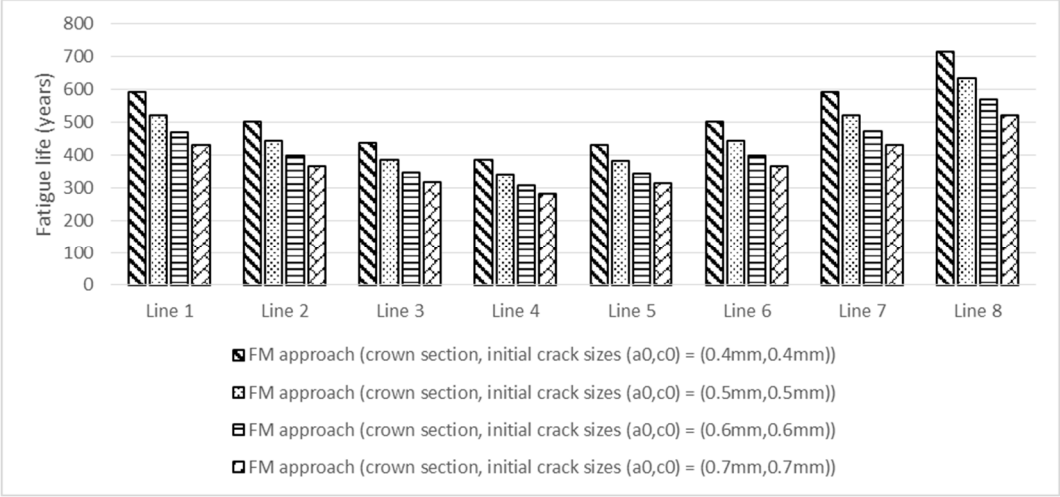
Figure 4.14: Fracture mechanics based fatigue analyses for mooring chain links with initial semi-elliptical surface cracks and initial semi-circle surface cracks for Case A: (a) Line 1 to Line 8; (b) Line 9 to Line 16

4.5.2 Effect of initial crack sizes

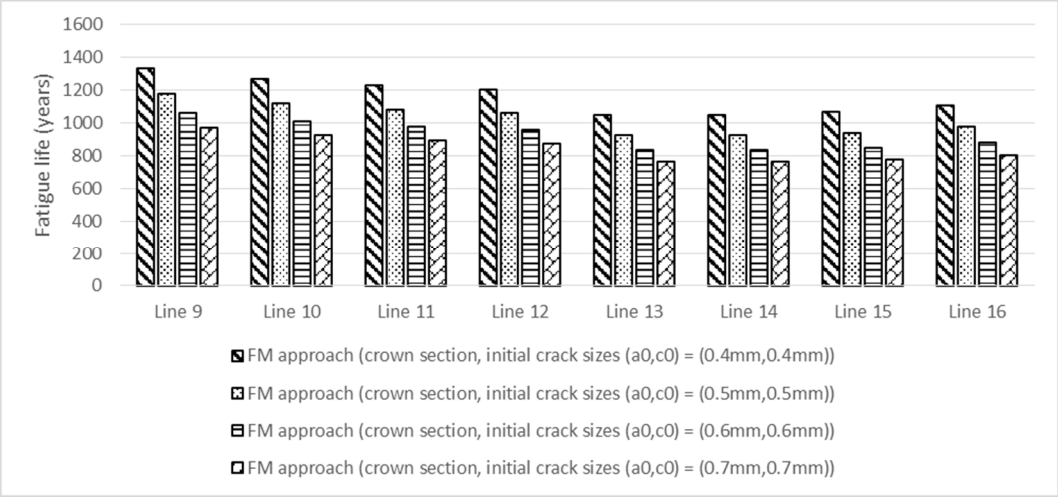
How to estimate the initial crack sizes of mooring chain links relating to different mooring chain diameters is not clarified in the literature.

Fatigue lives of crown sections of mooring chain links of the mooring system Case A calculated based on different initial crack sizes for Case A are plotted in Figure 4.15 where the assumed initial crack sizes (a_0, c_0) are selected as (0.4mm, 0.4mm), (0.5mm, 0.5mm), (0.6mm, 0.6mm), and (0.7mm, 0.7mm).

Figure 4.15 shows that the estimated fatigue lives decrease with the increase of initial crack sizes and the estimated fatigue lives calculated with initial crack sizes as (0.4mm, 0.4mm) are about 37% longer than those predicted with initial crack sizes as (0.7mm, 0.7mm) for identical mooring chains in this parametric study. It demonstrates that the fatigue lives of mooring chain links are generally sensitive to the assumed initial crack sizes and proper choice of the initial crack sizes is one of the key factors for accurate fatigue life prediction of mooring chain links.



(a)



(b)

Figure 4.15: Fracture mechanics based fatigue analyses for mooring chain links with different initial crack sizes (a_0, c_0) for Case A: (a) Line 1 to Line 8; (b) Line 9 to Line 16

4.5.3 Effect of critical crack depths

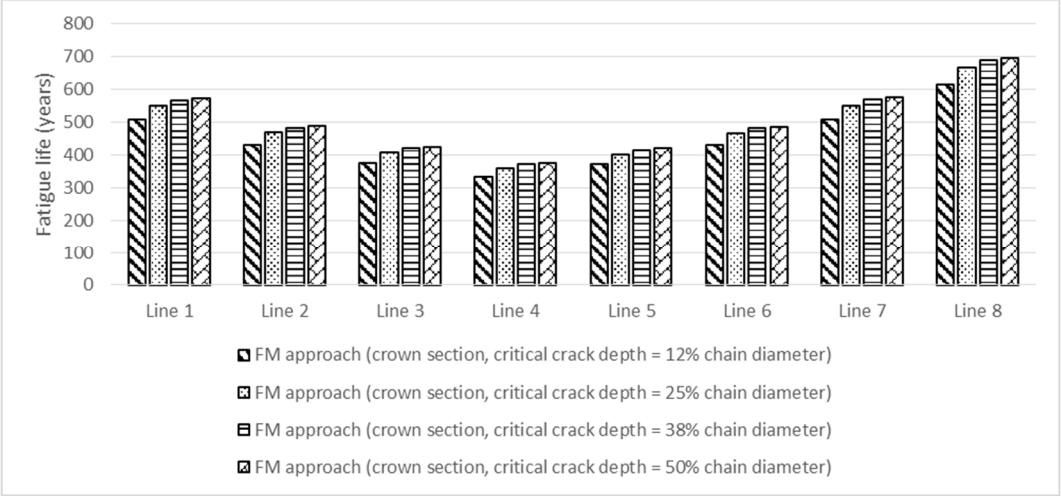
Mathisen and Larsen (2004) suggested different critical crack depths for various locations of mooring chain links in fracture mechanics analysis. However, there is no particular reason given to explain why these critical crack depths were chosen. A parametric study to investigate the effect of critical crack depths on the fatigue lives of mooring chain links is thus carried out in this Section.

The comparison of fatigue lives of crown sections of mooring chain links of the mooring system Case A predicted based on different critical crack depths are performed and the results are shown in Figure 4.16, in which the critical crack depths selected as 12%, 25%, 38% and 50% of mooring chain diameter are utilized for the parametric study.

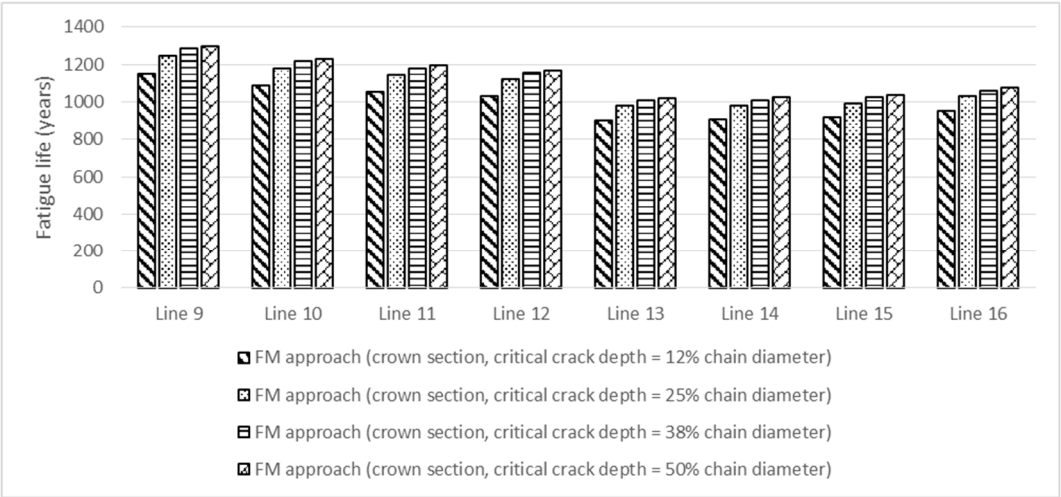
Figure 4.16 shows that fatigue lives calculated based on the critical crack depth chosen as 50% of mooring chain diameter are only 5% longer than those calculated based on the critical crack depth chosen as 13% of mooring chain diameter. It might be indicated that fatigue lives of crown sections of mooring chain links predicted by the fracture mechanics analysis are relatively less sensitive to the critical crack depth.

The crack evolution of the mooring chain link in Line 4 is plotted in Figure 4.17.. The crack grows rapidly after reaching 10% of the diameter. That might be the reason that the effect of

critical crack depths on fatigue life of mooring chain link is not significant when the critical crack depth is set more than 12% of mooring chain diameter in this study.



(a)



(b)

Figure 4.16: Fracture mechanics based fatigue analyses for mooring chain links with different critical crack depths for Case A: (a) Line 1 to Line 8; (b) Line 9 to Line 16

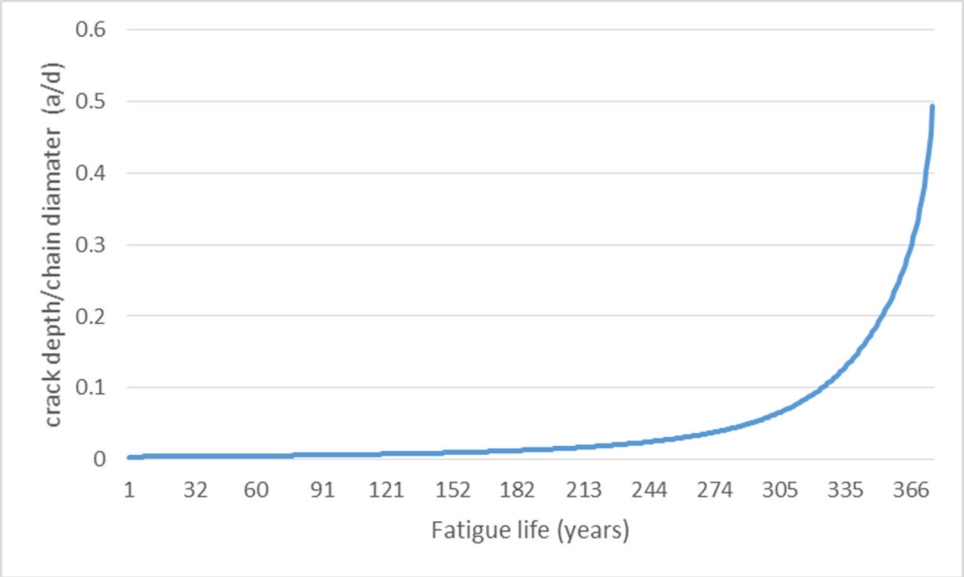


Figure 4.17: Crack evolution of the crown section of mooring chain link at the Line 4 fairlead in Case A

4.6 Summary

A fracture mechanics (FM) based mooring fatigue assessment approach is developed for offshore mooring systems. A comparison between T-N curves, S-N curves, and the FM based mooring fatigue assessment is made based considered mooring line tensions achieved in the Chapter 3, and the results show:

- The fatigue lives predicted by T-N curves, S-N curves, and FM based approaches are in general comparable if the safety factors suggested by API and DNVGL are considered in T-N and S-N curves based approaches.
- The T-N curves based approach is slightly conservative than the S-N curves based approach for fatigue life prediction of a mooring chain link.
- The fatigue life of a chain link at the weld section is very sensitive to the SCF that is primarily depending on the welding quality.
- The crown section of a mooring chain link is prone to fatigue damage compared to the bend section and the weld section without considering the SCF.

A parametric study to determine the influence of initial crack shape, critical crack depth and initial crack sizes on fatigue life prediction of mooring chain links are carried out, and the results show:

- The fatigue life of a mooring chain link calculated based on the initial semi-circle surface crack may be shorter than that calculated based on the initial semi-elliptical surface crack.
- The fatigue life of a mooring chain link is generally sensitive to the assumed initial crack sizes.
- The fatigue life of a mooring chain link predicted by the fracture mechanics analysis is relatively less sensitive to the critical crack depth.

According to the summaries achieved above, it can be concluded that the developed FM based mooring fatigue assessment can be applied for offshore mooring fatigue analysis.

Chapter 5. Fracture Mechanics (FM) based Fatigue Assessment for Mooring Lines Subjected to Bending

5.1 Introduction

As seen from the literature review, a mooring fatigue analysis is traditionally conducted based on T-N curves or S-N curves for mooring chain links subjected to pure tension, in which the effect of bending moment on the fatigue life of mooring chain link is ignored. Recently, industry codes (API RP 2SK, 2008) point out that the fatigue of a mooring chain link subjected to bending should be evaluated carefully, especially for a mooring system designed for permanent platform.

T-N curves or S-N curves based approaches presented in Chapter 4 can directly predict fatigue damage based on tension ranges or nominal stress ranges acting on mooring chain links, and it only includes tension induced fatigue. Due to the fact that the data for mooring chain links subjected to bending is insufficient for generating design fatigue curves (API RP 2SK, 2008), fatigue damage of mooring chain links subjected to bending cannot be carried out using T-N curves or S-N curves based approach directly.

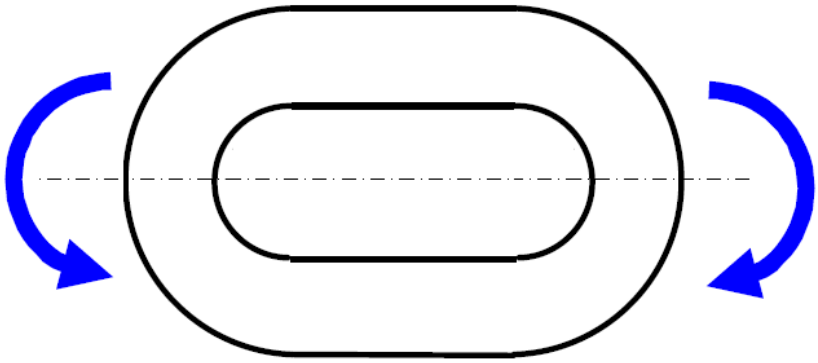
Unlike T-N curves or S-N curves based approach, the developed FM based approach estimates the crack growth based on the stress intensity factor (SIF) ranges, in which SIF ranges is calculated based on the local stress, not nominal stress. The FM based approach thus can be applied for predicting fatigue damage of mooring chain links subjected to bending.

In this chapter, the developed FM based mooring fatigue assessment approach is applied for mechanism investigation on mooring chain links subjected to out-of-plane bending (OPB), mooring chain links subjected to torque, and mooring chain links tensioned over a curved surface. The mooring line tensions of taut mooring system (Case A in Chapter 3) are considered for all the case studies in this chapter.

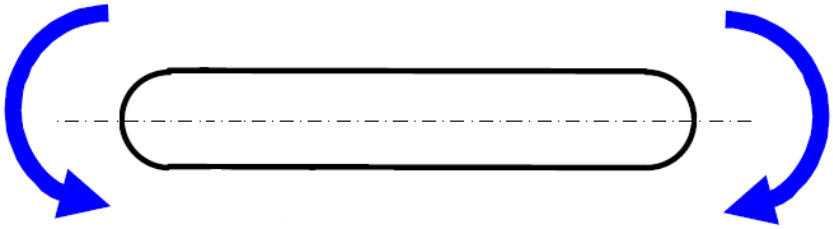
5.2 Fracture mechanics analysis for mooring chain links subjected to out-of-plane bending (OPB)

Depending on the directions of bending moments, as shown in Figure 5.1, bending modes of mooring chain links can be defined as:

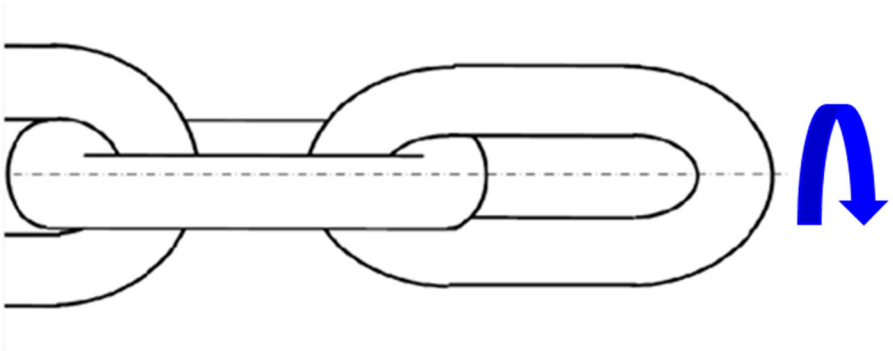
- An in-plane bending (IPB) mode where the mooring chain link is bent within the main plane of the mooring chain link;
- An out-of-plane bending (OPB) mode where the mooring chain link is bent out of the main plane of the mooring chain link;
- A torque mode where the mooring chain link is rotated along the centrelines of the mooring chain link.



(a)



(b)



(c)

Figure 5.1: Bending modes of mooring chain link: (a) IPB mode; (b) OPB mode; (c) Torque mode

Failure mode due to OPB is one of the important fatigue failure modes of mooring chain links. 3 of 29 mooring fatigue accidents reviewed by Fontaine et al. (2014) in Chapter 1 were induced by OPB. BV (2014) suggests addressing the effects of OPB on the mooring fatigue between common chain links. DNVGL OS E301 (2015) pointed out that the effects of OPB on the mooring fatigue should be considered for chain links directly contacted with other objects, e.g. mooring chain links connecting to the chain wheel, chain links passing over the bending shoes, chain links constraint provided by the chain hawse or chain stopper. API RP 2SK (2008) indicates that stress concentration factor (SCF) of mooring chain links directly contacted with other objects should be carefully evaluated by finite element (FE) analysis, especially for mooring systems designed for permanent platforms. However, there is still a lack of detailed guidance in industry design codes with respect to how to account for OPB effects caused by direct contact with other objects in a mooring fatigue analysis. There is thus a pressing need to investigate the mechanism of OPB and its effects on fatigue lives of mooring chain links.

In this section, an FM based investigation on the mechanism of out-of-plane bending (OPB) between mooring chain links and its effects on fatigue lives of mooring chain links are conducted. Four types of OPB problems that mooring chain links laying on the chain wheel, chain links passing over the bending shoe, chain links constraint provided by the chain hawse and chain links constraint provided by the chain stopper are considered.

5.2.1 Out-of-plane bending (OPB) of mooring chain link

In general, three frictional mechanisms can be considered to describe the behaviours of the mooring chain links with interlink angles, namely rolling, sliding and locking (Vargas and Jean, 2005). The rolling and sliding mechanism can be applied to common mooring chain links under low tension, in which the flat-links are assumed to roll or to slide on the inner surface of the adjacent upright-links, and the frictions between mooring chain links would arise OPB moment M_{opb} acting on the flat-link as:

$$M_{opb} = \frac{1}{2} d F_{Fri} \tag{5.1}$$

where d is the nominal diameter of the chain link, and F_{Fri} the friction between adjacent mooring chain links.

The locking mechanism can be applied to the mooring chain links under high tension or locked-up with fixed interlink angles decided by the mooring equipment during the operation. Considering the three mooring chain links as shown in Figure 5.2, the flat-link (Link 2) is subjected to OPB and OPB moment M_{opb} at the left end of Link 2 can be calculated as:

$$M_{opb} = M_r + T(D_x sin\alpha - D_y cos\alpha) \tag{5.2}$$

in which M_r is the bending moments leading the rotation of mooring chain link, α the applied load angle, which can be considered as the summation of interlink angles 1 and 2. D_x and D_y are horizontal and vertical distances, as shown in Figure 5.2, respectively.

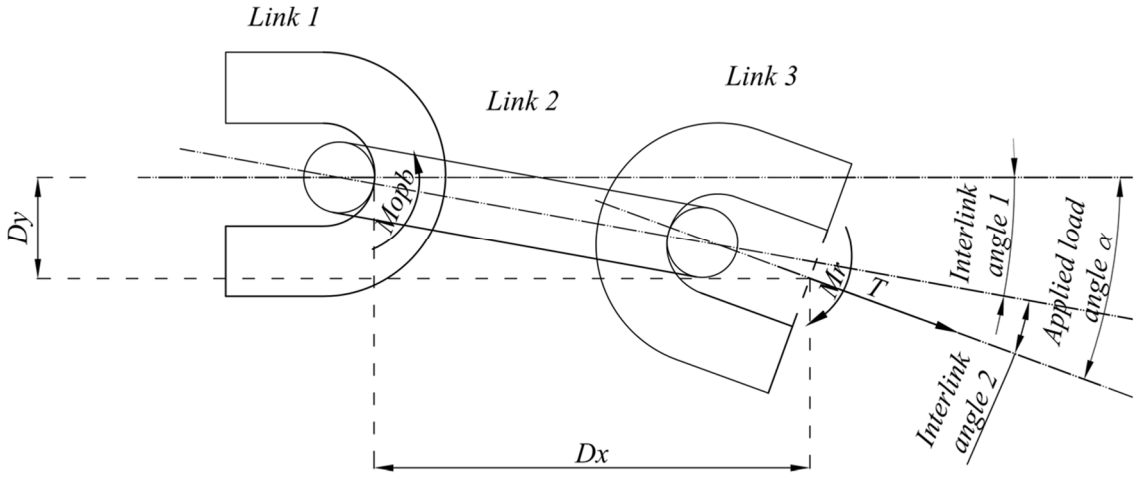


Figure 5.2: Mooring chain links subjected to OPB

There are different reasons why the interlink angles between mooring chain links are generated or locked up for different devices utilized in the offshore mooring system. A fairlead is a

common offshore device used to guide a mooring line operating around the platform, keeping it clear of obstructions and preventing it from cutting or chafing. In the fairlead applied in the offshore platform, a chain wheel or a bending shoe is generally installed to guide the top mooring line, and the mooring chain links passing over the fairlead are considered to be set in the groove of the chain wheel or the bending shoe. The interlink angles between mooring chain links contacted with the fairlead are then decided by the number of the pockets of the chain wheel or the character of the bending shoe.

Figure 5.3 is the sketch of mooring chain links laying on the chain wheel from two view directions, showing that the flat-link (Link 2) within the chain wheel is subjected to OPB induced by the tension forces in the adjacent upright-links and the support forces provided by bearing a plate of the chain wheel. Figure 5.4 shows a typical kind of bending shoes, in which a longitudinal groove is welded at the curved track, and the flat-links passing over the bending shoe might be situated on the surface of the groove, and these flat-links would be subjected to OPB due to the interlink angles induced by the curved surface of the track.

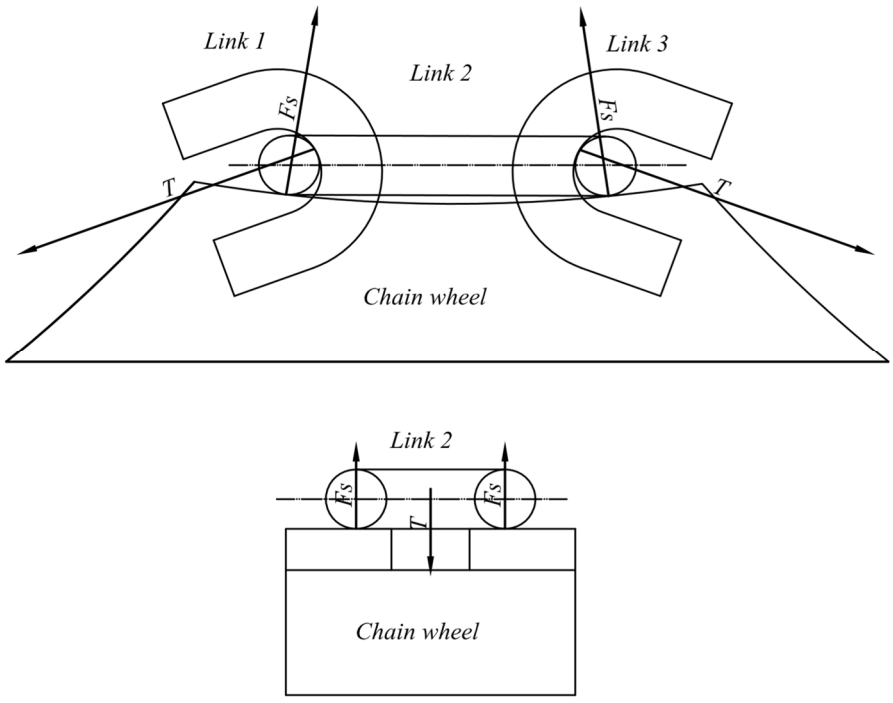


Figure 5.3: Sketch of mooring chain laying on the chain wheel

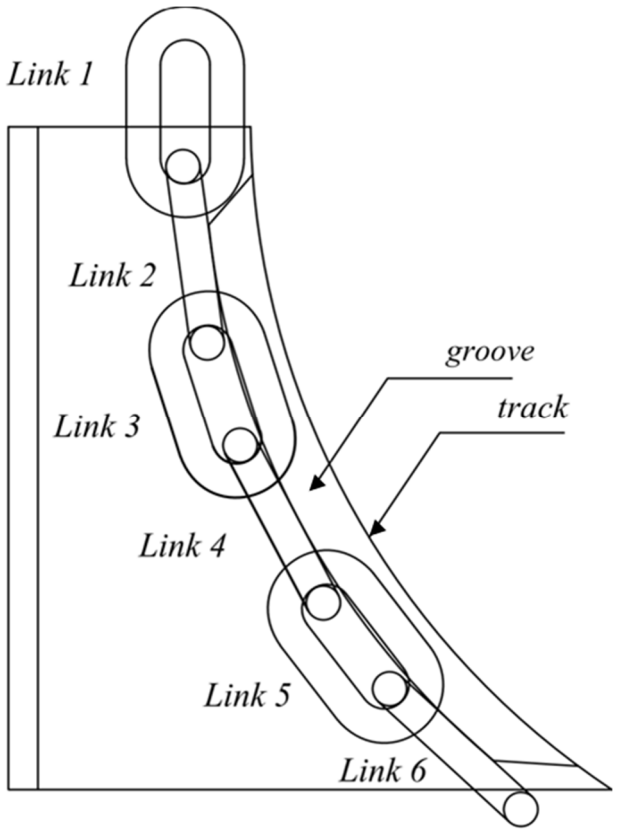


Figure 5.4: Sketch of mooring chain passing over the bending shoe

A chain hawse is a hawse pipe passing over the offshore structure that the mooring line passes through. A chain stopper is a fitting device riding at the mooring chain link, which is designed to secure the mooring line. These two mooring devices are usually designed in conjunctive use to guide mooring chain links, and the reasons interlink angles arise between mooring chain links provided by the chain hawse and chain stopper are relatively complex due to various design and arrangement of these devices (API RP 2SK, 2008).

Figure 5.5 shows an arrangement of the mooring chain links passing through a fixed chain hawse that cannot rotate according to the motions of mooring line and fairlead characteristics. As shown in Figure 5.5, during the operation, upright chain links (Links 4 and 6) may contact the hawse wall and trumpet, which would arise certain interlink angles acting on the flat-link (Link 5) near the trumpet of the chain hawse.

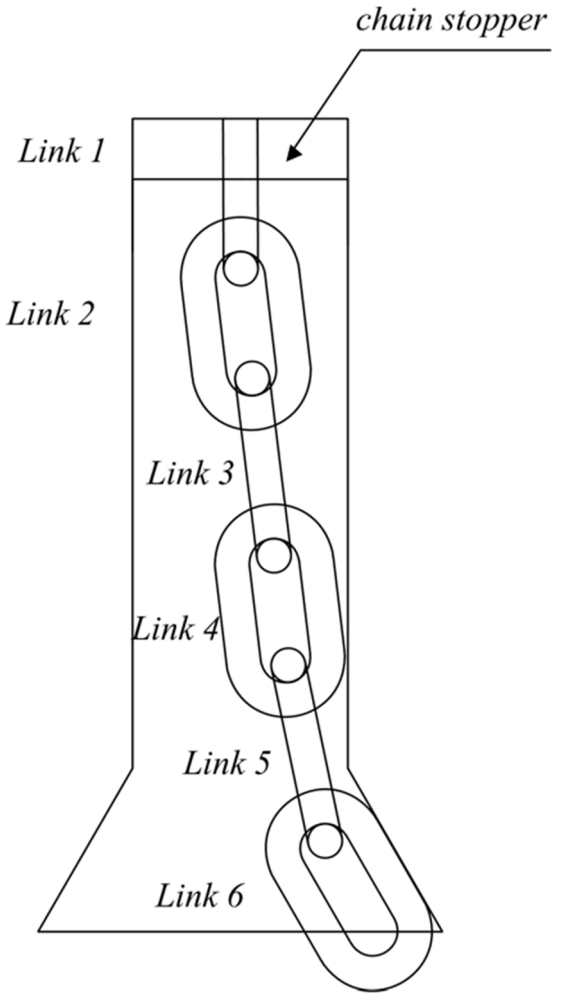


Figure 5.5: Sketch of mooring chain constraint provided by the chain hawse

Figure 5.6 shows another type of chain hawse and stopper that sliding mechanism between mooring chain links can be applied. In this kind of device, the chain stopper plate would rotate to be perpendicular to the chain links automatically after the mooring line contacts with the hawse wall. As a result, the first flat-link from the chain stopper would keep rotating during the operating at sea, and this chain link would be subjected to OPB.

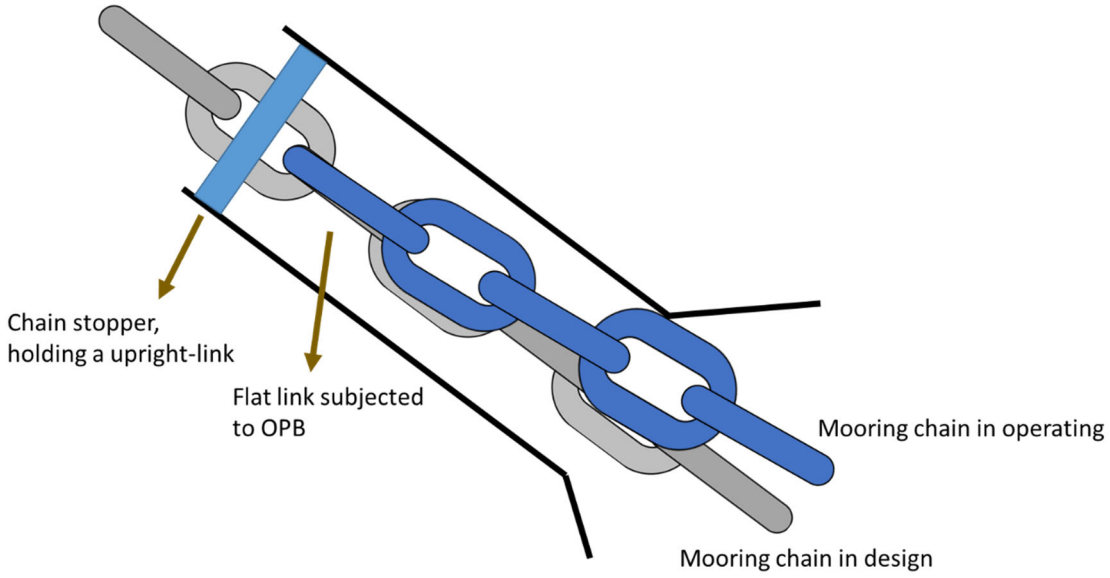


Figure 5.6: Sketch of mooring chain constraint provided by the chain stopper

5.2.2 Finite element analysis of mooring chain links subjected to OPB

A series of finite element (FE) analyses using ANSYS workbench with an implicit solver are performed to measure OPB induced stresses on mooring chain links. Four types of OPB scenarios are considered, namely, 1) mooring chain links laying on the chain wheel; 2) mooring chain links passing over the bending shoe; 3) chain links constraint provided by the chain hawse; 4) chain links constraint provided by the chain stopper. The contact effects between mooring chain links and mooring equipment are considered, and the contact equation is given as:

$$F_{normal} = k_{normal} x_{penetration} \tag{5.3}$$

where F_{normal} is the contact force, k_{normal} the contact stiffness, $x_{penetration}$ the penetration.

All of the mooring chain links in the selected mooring system are 6 inch R4 class studless chain links and they are modelled with standard dimensions considering a corrosion and wear allowance of 25 years. Mooring chain links are meshed with quadratic hexahedron with the element size of 10 to 20 mm.

5.2.2.1 Mooring chain links laying on chain wheels

This scenario is modelled as shown in Figure 5.7. Three types of chain wheels are considered, namely, 5-pocket, 7-pocket and 9-pocket chain wheels, and all of the chain wheels are simplified as bearing plates with fixed support. The model of two half upright-links and one full flat-link is built, and the sliding behaviour of contact regions between chain links and the chain wheel, and each chain link are taken into account, which means that mooring chain links are allowed to slide along the surface of chain wheel and adjacent chain links. Tension forces at the fairlead of the mooring system are then applied at Ends B and C by pressure. Mooring chain links are set with an initial interlink angles depending on the number of pockets (36 degrees for 5-pockets chain wheel, 25.71 degrees for 7-pockets chain wheel, and 20 degrees for 9-pockets chain wheel).

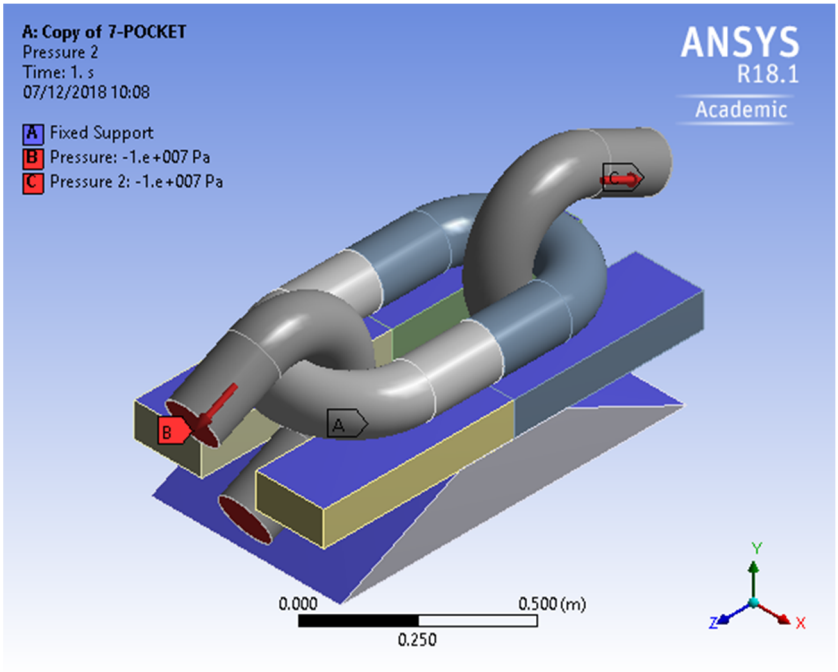


Figure 5.7: Finite element model of the scenario that mooring chain link laying on the chain wheel

5.2.2.2 Mooring chain links passing over bending shoes

This scenario is modelled, as shown in Figure 5.8. The curved grooves that are welded at tracks of the bending shoes with diameters of 9 m, 7 m, and 5 m, respectively, are considered as bearing plates with fixed support. The model of two half-links and three full flat-link is built, and the sliding behaviour of contact regions between full chain links and the curved groove are

accounted. Tension forces at the fairlead of the mooring system are then applied at the End B by pressure, and End C is treated as a simply supported end.

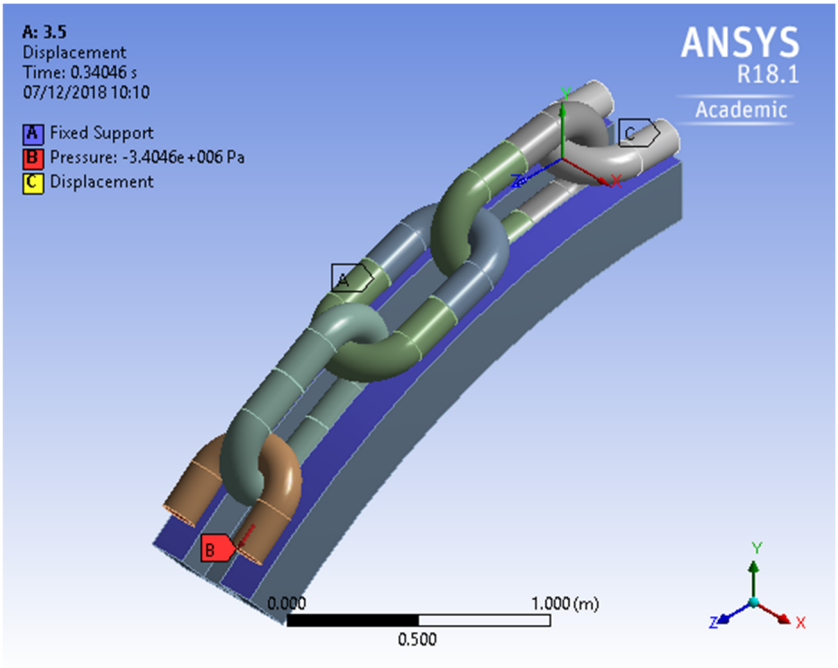


Figure 5.8: Finite element model of the scenario that mooring chain links passing over the bending shoe

5.2.2.3 Mooring chain links constraint provided by chain hawses

In this scenario, 2.5 m-long round chain hawses combined with trumpets are modelled, and the diameters of chain hawses are considered as 0.760 m, 0.912 m and 1.064 m (5, 6 and 7 times as the nominal diameter of the mooring chain links) respectively, as shown in Figure 5.9. Then six mooring chain links including two half links and four full flat-links are built inside the chain hawse. The first half link with fixed ends (End A) are considered as the chain link provided by the chain stopper, and the following mooring chain links are pre-rotated to the operating angles as shown in Figure 5.5. Then the tension forces at the fairlead of the mooring system are applied at the End C in Figure 5.9 by pressure. The inner surfaces of the pipe wall and trumpet are treated as bearing plate with fixed support.

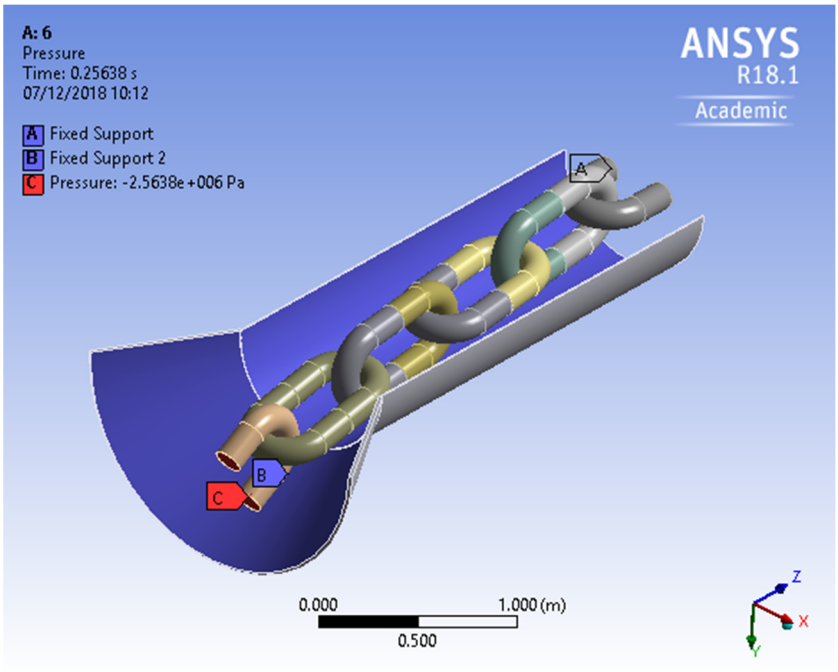


Figure 5.9: Finite element model of mooring chain links constraint provided by the chain hawse

5.2.2.4 Mooring chain links constraint provided by chain stoppers

In this scenario, three mooring chain links (two half upright-links and one full flat-link) are modelled in the FE analysis, as shown in Figure 5.10. The first half upright-link is considered as the chain link provided by the chain stopper, and the end face (End B) of this chain link is fixed. Tension forces at the fairlead of the mooring system are applied at the ends of the third mooring chain link (End A) by pressure, then bending moments are applied at End A as well to rotate mooring chain links to the interlink angles of 1, 2, 3, 4 and 5 degrees, respectively.

The effect of the proof loading test is generally ignored during the fatigue analysis of mooring chain links, such as the circumstances of mooring chain links subjected to pure tension, mooring chain links connecting to the chain wheel, chain links passing over the bending shoe, and chain links constraint provided by the chain hawse, in which chain links in these models are considered to be connected with a pre-set interlink angle. For mooring chain links provided by chain stoppers, the effect of proof loading test has been taken into account. In this case, the contact region between mooring chain links would be larger than the mooring chain links without the proof loading test due to the local plastic deformation induced by the proof loading test, and the behaviour between mooring chain links would be affected when the rotation angle is applied to the model.

To include the effects of the proof loading test, three loading steps are applied in the analysis:

1) Apply the proof loading at the chain links
2) Unload the proof loading
3) Apply operating loading at the two half chain links

where proof loading can be calculated as (DNVGL OS E302, 2015):

$$F_P = 0.0192d^2(44 - 0.08d) \tag{5.4}$$

In addition, a parametric study to investigate the effects of the friction coefficient presented in Equation 5.1 on the fatigue lives of mooring chain links is also conducted.

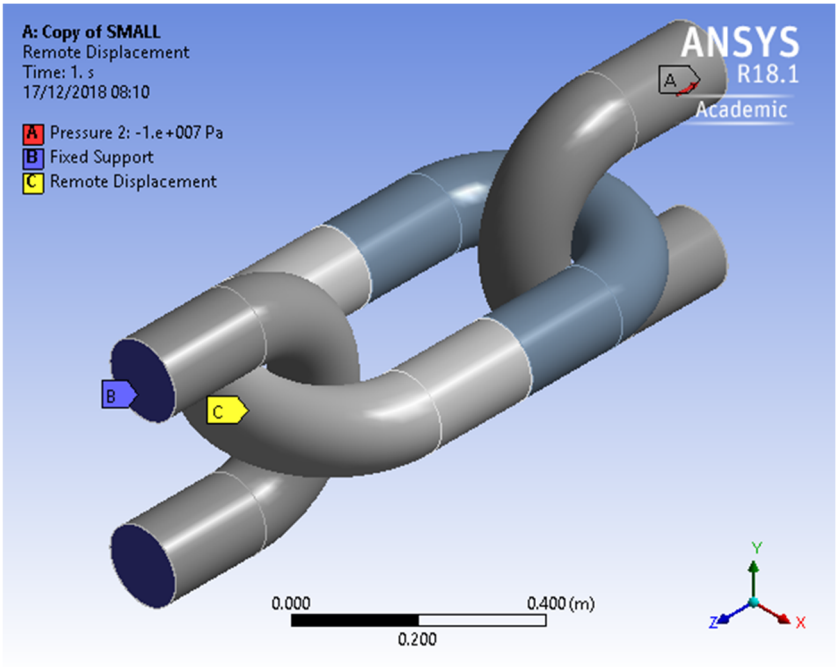


Figure 5.10: Finite element model of mooring chain links constraint provided by the chain stopper

5.2.3 Results and discussion

The effects of OPB on fatigue lives of mooring chain links laying on the chain wheel, chain links passing over the bending shoe, chain links constraint provided by the chain hawse and the chain stopper, are discussed separately in this section. Figure 5.11 gives the sketch of the mooring chain link with defined angles to assist in describing the location of the hot spot at the mooring chain links.

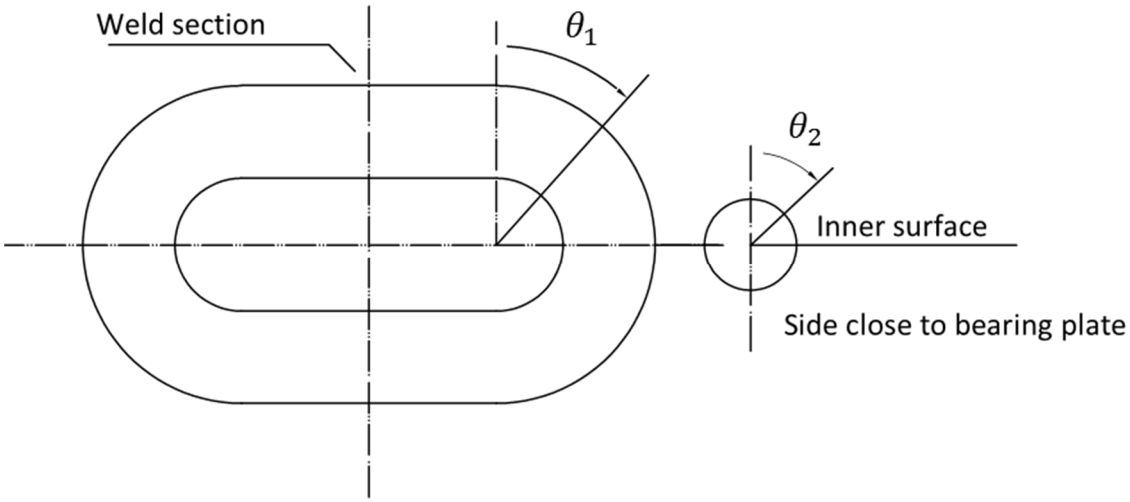


Figure 5.11: sketch of mooring chain links

All the fatigue lives of mooring chain links examined by the FM method considered a simplified model with the initial semi-elliptical surface crack size (a_0, c_0) of (0.5mm, 0.5mm), and the critical crack size as 12% of chain diameter. Also, Chapter 4 shows that Line 4 is the most critical mooring line to suffer from fatigue damage among 16 mooring lines, thus only the fatigue lives of mooring chain links subjected to OPB in Line 4 are discussed in this section.

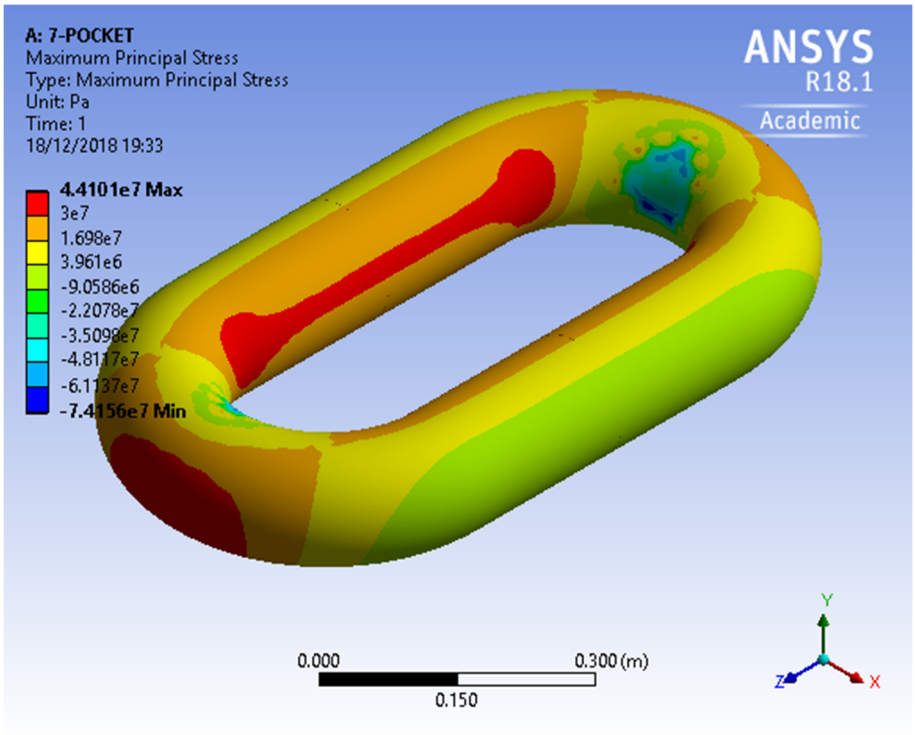
In addition, the effects of OPB on fatigue lives of mooring chain links are represented by the ratio of fatigue life that is defined herein as a ratio of a mooring chain link subjected to OPB to that not subjected to OPB.

5.2.3.1 Mooring chain links laying on chain wheels

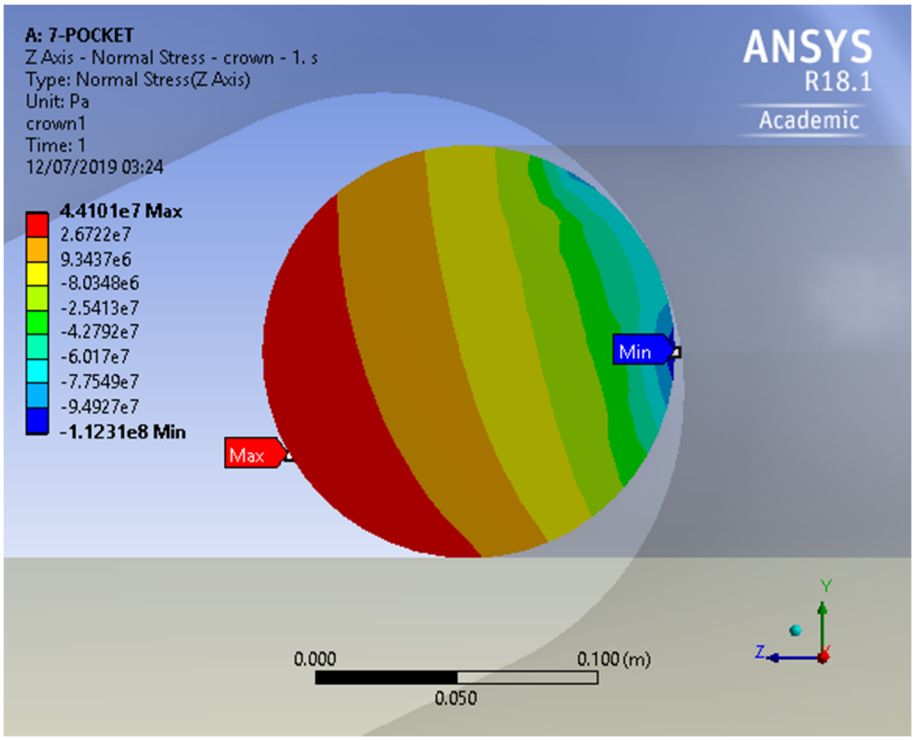
The maximum principal stress and normal stress at the cross-section prone to fatigue of the flat-link laying on the chain wheel is shown in Figure 5.12. Figure 5.12 shows that the hot spot is located at the lower outside surface of crown section (towards the bearing plate), and the crown section of the flat-link would have the lowest fatigue life if no SCF due to structural discontinuities is applied at weld section. The SCFs and locations for hot spots at flat-links laying on 5-pocket, 7-pocket and 9-pocket chain wheels are listed in Table 5.1.

Table 5.1: SCFs and locations of hot spots on mooring chain links laying on 5-pocket, 7-pocket, and 9-pocket chain wheels

	5 pocket	7 pocket	9 pocket
SCF	4.50	4.41	4.40
Section	$\theta_1 = 90°$	$\theta_1 = 90°$	$\theta_1 = 90°$
Location	$\theta_2 = 225°$	$\theta_2 = 240°$	$\theta_2 = 240°$



(a)



(b)

Figure 5.12: Stress distribution of the mooring chain link subjected to OPB laying on the chain wheel: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue

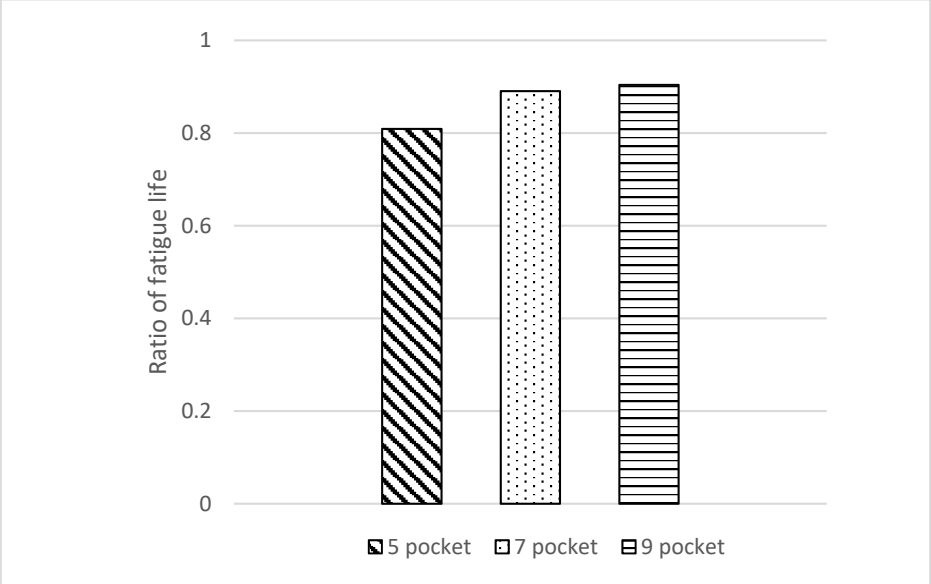


Figure 5.13: The ratios of fatigue lives of crown sections of mooring chain links laying on 5-pocket, 7-pocket, and 9-pocket chain wheels to those not subjected to OPB

The ratios of fatigue lives of crown sections of flat-links laying on 5-pocket, 7-pocket, 9-pocket chain wheels calculated by the FM method to those of the chain link not subjected to OPB are

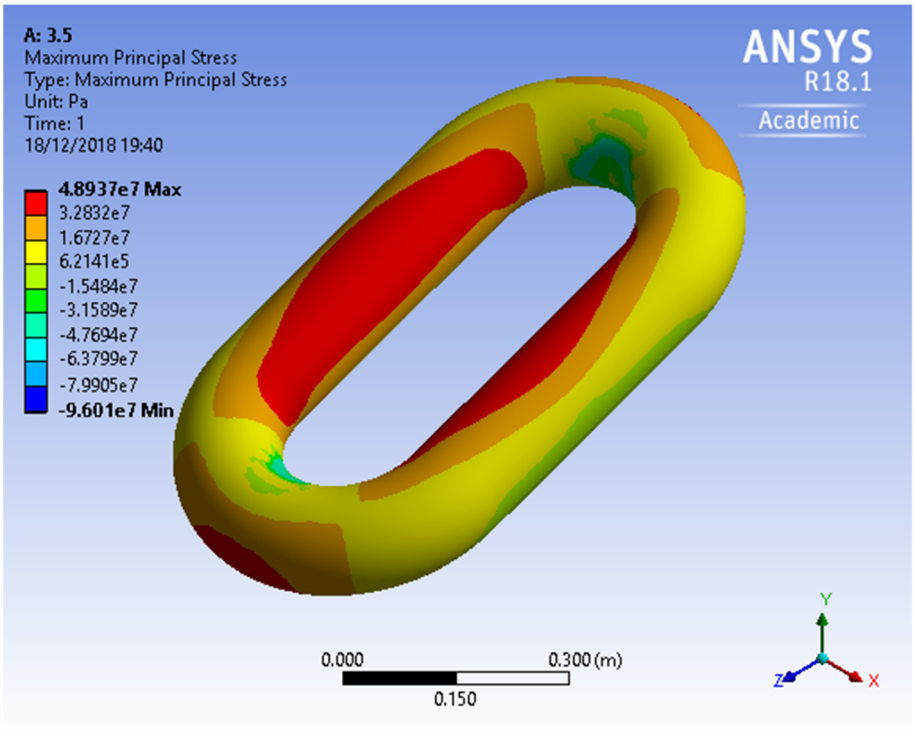
plotted in Figure 5.13. Figure 5.13 shows that the effects of OPB on the fatigue lives of mooring chain links laying on the chain wheel are obvious and fatigue lives of mooring chain links laying on 5-pocket, 7-pocket and 9-pocket chain wheels are decreased as much as 19%, 11% and 9%, respectively, of those of mooring chain links not subjected to OPB. In addition, with the increasing of the number of pockets of chain wheels, fatigue lives of mooring chain links increase as well.

5.2.3.2 Mooring chain links passing over bending shoes

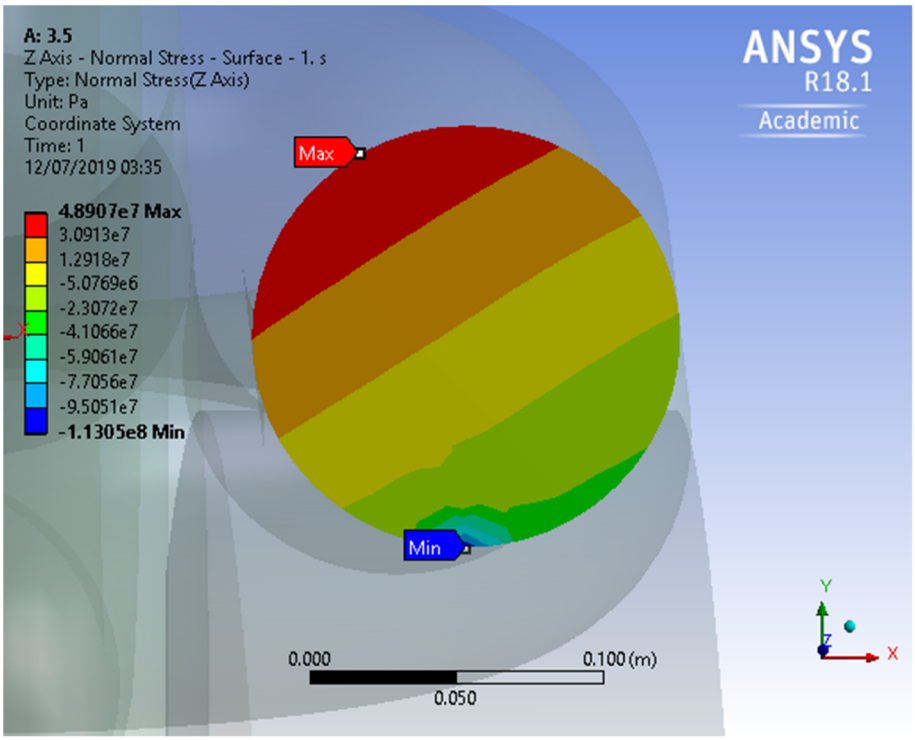
The maximum principal stress and normal stress at the cross-section prone to fatigue of the flat-links subjected to OPB (link 4 in Figure 5.4) in this scenario is shown in Figure 5.14. Figure 5.14 shows that the hot spot is located at the upper inner side surface of the weld section (away from the bearing plate), and the weld section would have the lowest fatigue life. The SCFs and locations of hot spots on chain links passing over the bending shoes considering track diameters of 5m, 7m and 9 m are listed in Table 5.2.

Table 5.2: SCFs and locations of hot spots on mooring chain links passing over bending shoes considering tracks with diameters of 5 m, 7 m and 9 m

	Diameter = 5 m	Diameter = 7 m	Diameter = 9 m
SCF	6.02	4.89	4.27
Section	Weld section	Weld section	Weld section
Location	$\theta_2 = 30°$	$\theta_2 = 30°$	$\theta_2 = 75°$



(a)



(b)

Figure 5.14: Stress distribution of the mooring chain link subjected to OPB passing over the bending shoe: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue

The ratios of fatigue lives of the weld sections of mooring chain links passing over bending shoes considering different sizes of tracks estimated by the FM method to those of the chain links not subjected to OPB are plotted in Figure 5.15. Figure 5.15 shows that fatigue lives of mooring chain links passing over bending shoes with track diameters of 5 m, 7 m and 9 m are only 9%, 19% and 31% of those of chain links not subjected to OPB, respectively, which means that fatigue lives of mooring chain links passing over the bending shoe drop dramatically with the deceasing of the track diameter and they are quite sensitive to the diameter of the track.

Figure 5.15: The ratios of fatigue lives of weld sections of mooring chain links passing over bending shoes considering tracks with diameters of 5 m, 7 m and 9 m to those not subjected to OPB

5.2.3.3 Mooring chain links constraint provided by chain hawses

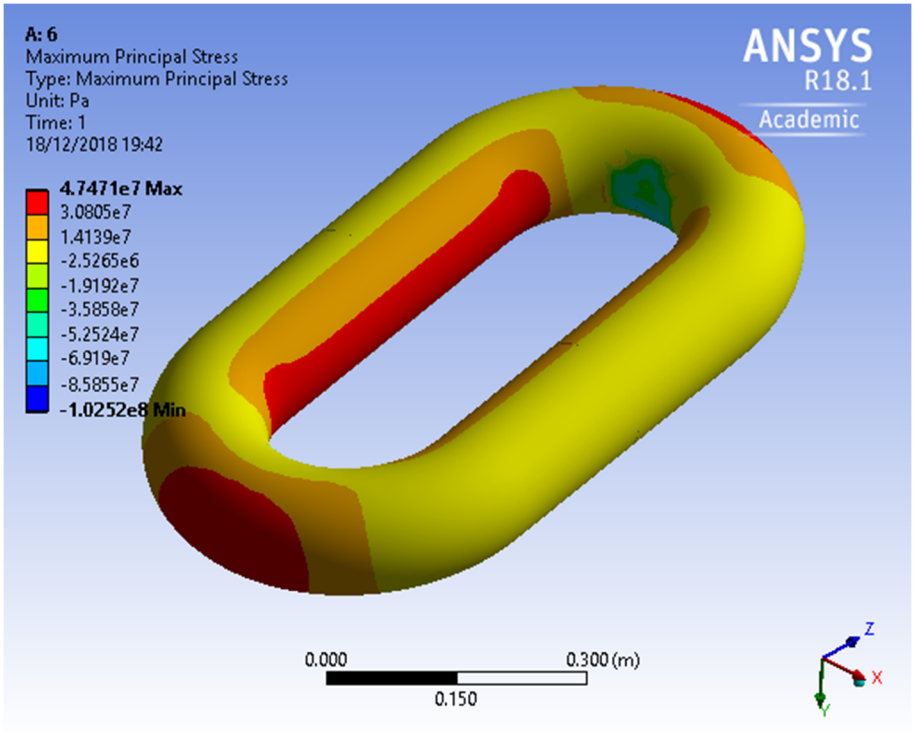
The maximum principal stress and normal stress at the cross-section prone to fatigue of the flat-links subjected to OPB (Link 5 in Figure 5.5) is shown in Figure 5.16. It shows that the hot spot is located near the middle of the outside surface of crown section, and the crown section of the flat-link would have the lowest fatigue life if no extra SCF is applied at weld section. The SCFs and locations of hot spots on mooring chain links constraint provided by chain hawses with diameters of 0.760 m, 0.912 m and 1.064 m are listed in Table 5.3.

The ratios of fatigue lives of crown sections of mooring chain links subjected to OPB constraint provided by chain hawses with diameters of 0.760 m, 0.912 m and 1.064 m calculated by the

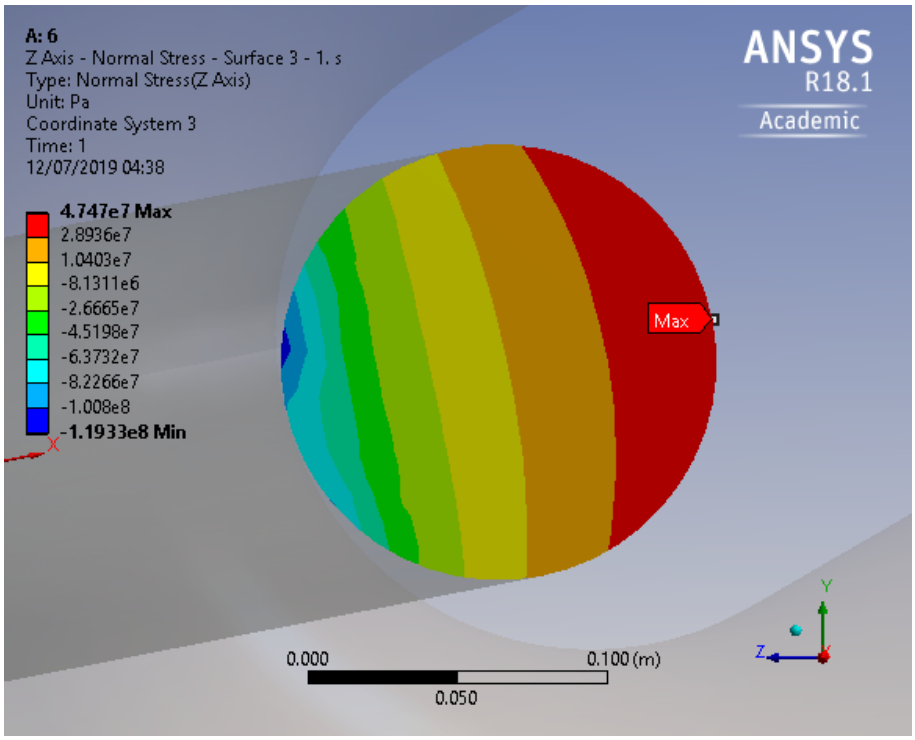
FM method to those of the chain link not subjected to OPB are plotted in Figure 5.17. Figure 5.17 shows fatigue lives of mooring chain links constraint provided by chain hawses with diameters of 0.760 m, 0.912 m and 1.064 m are 74%, 73% and 72% of those of the chain link not subjected to OPB, respectively, which means that the contacting with the hawse wall and trumpet has evident effects on the fatigue lives of mooring chain links subjected to OPB, while the effects of the diameter of chain hawse on the fatigue lives of mooring chain links subjected to OPB are limited if without the abrupt change of the contact conditions between the chain links and chain hawse.

Table 5.3: SCFs and locations of hot spots on mooring chain links constraint provided by chain hawses with diameters of 0.760 m, 0.912 m and 1.064 m

	Diameter = 0.760 m	Diameter = 0.912 m	Diameter = 1.064 m
SCF	4.70	4.75	4.78
Section	$\theta_1 = 90°$	$\theta_1 = 90°$	$\theta_1 = 90°$
Location	$\theta_2 = 270°$	$\theta_2 = 270°$	$\theta_2 = 270°$



(a)



(b)

Figure 5.16: Stress distribution of the mooring chain link subjected to OPB constraint provided by the chain hawse: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue

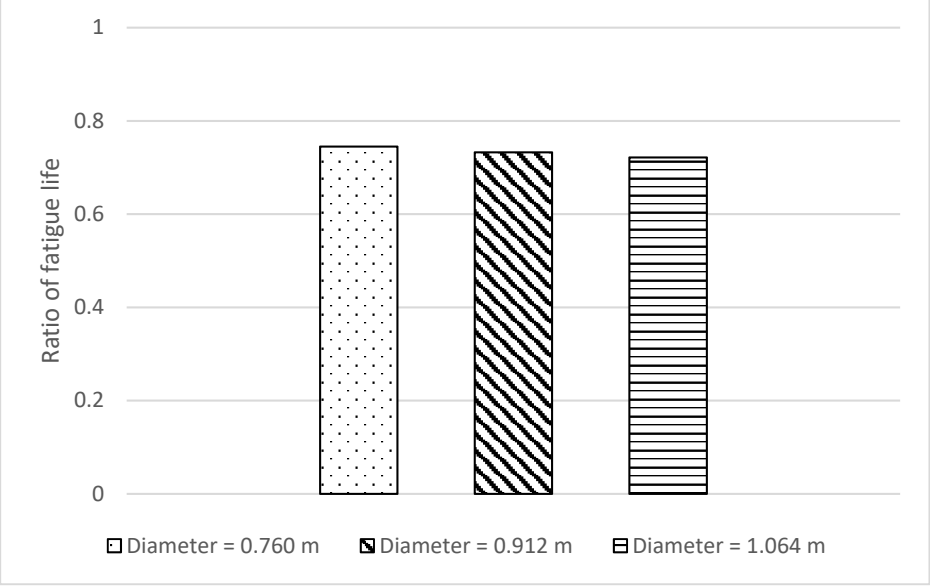


Figure 5.17: The ratios of fatigue lives of crown sections of mooring chain links constraint provided by chain hawses with diameters of 0.760 m, 0.912 m and 1.064 m to those not subjected to OPB

5.2.3.4 Mooring chain links constraint provided by chain stoppers

In this scenario, the effect of proof loading test has been taken into account. The maximum principal stress and normal stress at the cross-sections prone to fatigue of the flat-links subjected to OPB are plotted in Figure 5.18. Figure 5.18 shows that the hot spot would move to the middle of the inner surface of bend section, and the largest fatigue damage would occur at this section. The SCFs of hot spots on mooring chain links constraint provided by chain stopper with the interlink angles of 1, 2, 3, 4 and 5 degrees considering friction coefficients of 0.1, 0.3, and 0.5 are listed in Tables 5.4 to 5.6.

The ratios of fatigue lives of crown sections of mooring chain links subjected to OPB constraint provided by chain stopper with the interlink angles of 1, 2, 3, 4 and 5 degrees considering different friction coefficients calculated by the FM method to those of the chain link not subjected to OPB are plotted in Figure 5.19. Figure 5.19 shows that fatigue lives of bend sections of mooring chain links constraint provided by chain stopper are very sensitive to the friction coefficients. The fatigue lives of bend sections subjected to OPB are approximately 64% to 73%, 43% to 53% and 34% to 48% of those of the common chain link not subjected to OPB for considering a friction coefficient of 0.1, 0.3, and 0.5, respectively. In addition, the fatigue lives of mooring chain links would drop obviously with the increase of the interlink angles though the interlink angles are still between 1 to 5 degrees.

Table 5.4: SCFs of hot spots on mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 with friction coefficient of 0.1

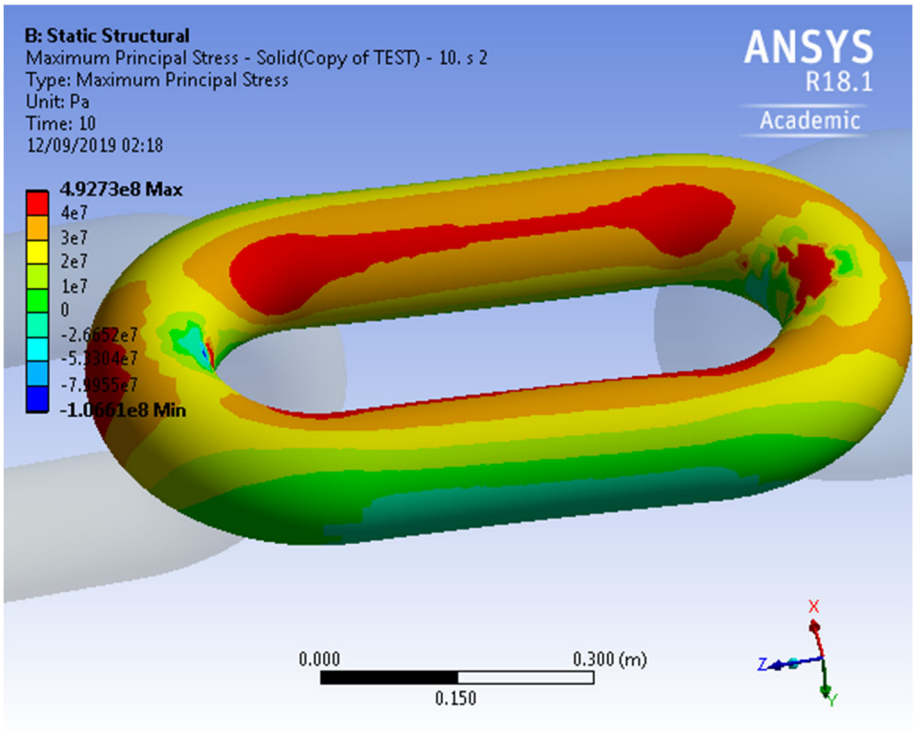
	1 Degree	2 Degrees	3 Degrees	4 Degrees	5 Degrees
SCF	4.42	4.46	4.49	4.53	4.57
Section	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$
Location	$\theta_2 = 75°$	$\theta_2 = 75°$	$\theta_2 = 75°$	$\theta_2 = 75°$	$\theta_2 = 75°$

Table 5.5: SCFs of hot spots on mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 with friction coefficient of 0.3

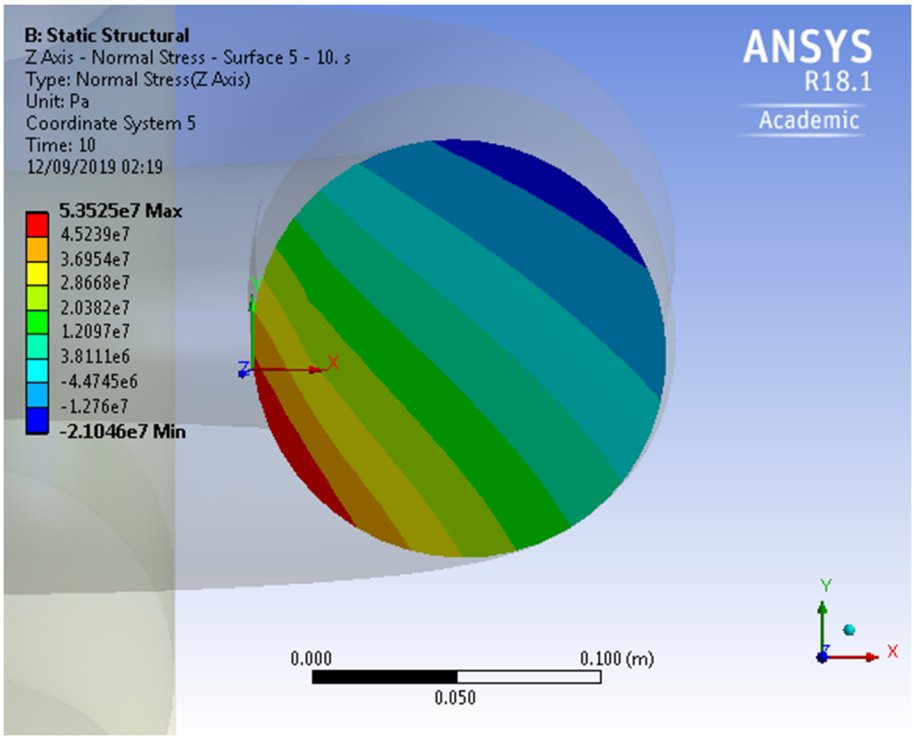
	1 Degree	2 Degrees	3 Degrees	4 Degrees	5 Degrees
SCF	4.82	4.93	4.98	5.07	5.12
Section	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$
Location	$\theta_2 = 75°$	$\theta_2 = 60°$	$\theta_2 = 60°$	$\theta_2 = 60°$	$\theta_2 = 60°$

Table 5.6: SCFs of hot spots on mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 with friction coefficient of 0.5

	1 Degree	2 Degrees	3 Degrees	4 Degrees	5 Degrees
SCF	4.95	5.30	5.41	5.45	5.46
Section	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$	$\theta_1 = 10°$
Location	$\theta_2 = 52.5°$	$\theta_2 = 52.5°$	$\theta_2 = 52.5°$	$\theta_2 = 52.5°$	$\theta_2 = 52.5°$



(a)



(b)

Figure 5.18: Stress distribution of the mooring chain link subjected to OPB constraint provided by the chain stopper: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue

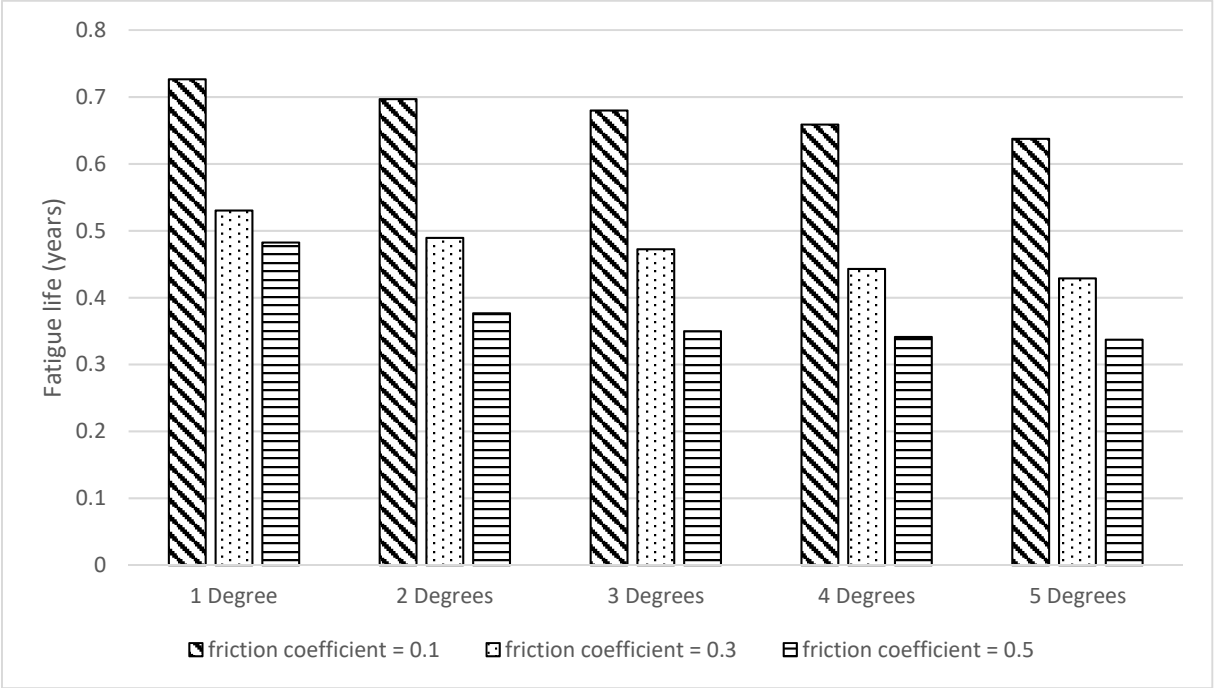


Figure 5.19: The ratios of fatigue lives of mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 degrees to those not subjected to OPB

5.2.4 Summary

The mechanism of four types of OPB problems that mooring chain links laying on the chain wheel, chain links passing over the bending shoe, chain links constraint provided by the chain hawse, chain links constraint provided by the chain stopper was investigated, and the effects of four types of OPB on fatigue lives of chain links were evaluated by the developed FM based mooring fatigue assessment and mooring line tensions achieved from Chapter 3. The results indicated that:

- Fatigue lives of mooring chain links are decreased significantly due to OPB effects induced by the interlink angle between adjacent mooring chain links.
- For mooring chain links laying on chain wheel, the increase of the number of pockets of chain wheel diminishes OPB influence on fatigue life reduction of chain links. The crown section is the most critical section prone to fatigue damage. Fatigue lives of crown sections of mooring chain links laying on 5-pocket, 7-pocket and 9-pocket chain wheels are decreased as much as 19%, 11% and 9%, respectively, of those not subjected to OPB.
- For mooring chain links passing over bending shoes, the increase of the track diameter would reduce OPB effects on the fatigue lives of mooring chain links. The weld section is the most critical section prone to fatigue damage. The fatigue lives of weld sections of mooring chain links passing over bending shoes with track diameters of 5 m, 7 m and 9 m are only 9%, 19% and 31%, respectively, of those not subjected to OPB.
- For mooring chain links constrained by chain hawses, the crown section is the most critical section prone to fatigue damage. Fatigue lives of mooring chain links constraint provided by chain hawses with diameters of 0.760 m, 0.912 m and 1.064 m are 74%, 73% and 72% of those not subjected to OPB, respectively,. The diameter variation of the chain hawses has thus no obvious effects on fatigue lives of mooring chain links subjected to OPB without the abrupt change of the contact conditions between the chain links and chain hawse.
- For mooring links constraint provided by chain stoppers, the bend section is the most critical section prone to fatigue. Fatigue lives of bend sections of mooring chain links constraint provided by chain stoppers are very sensitive to friction coefficients. The fatigue lives of bend sections subjected to OPB are approximately 64% to 73%, 43% to 53% and 34% to 48% of those not subjected to OPB for considering a friction coefficient of 0.1, 0.3, and 0.5, respectively. In addition, the fatigue lives of mooring chain links would drop obviously with the increase of the interlink angles though the interlink angles are still between 1 to 5 degrees.

5.3 Fracture mechanics analysis for mooring chain links subjected to torque

Theoretically, an axial load applying at the mooring chain does not generate chain twist. However, in the engineering practice, the chain twist exists and it causes torque loads between chains, and the reasons causing the chain twist is discussed in the Section 2.4.

In the API RP 2SK (2008), it is highlighted that stored or trapped torque in the mooring chain can pose a significant safety hazard to personnel. However, there is still a lack of detailed guidance in industry design codes with respect to how to account for torque effects induced by chain twist in a mooring fatigue analysis. There is thus a pressing need to investigate the mechanism of torque and its effects on fatigue lives of mooring chain links.

In this section, a fracture mechanics (FM) based investigation on the mechanism of torque between mooring chain links and its effects on fatigue lives of mooring chain links are conducted.

5.3.1 Torque of mooring chain link

The sketch of mooring chain with twist angle is shown in Figure 5.20.

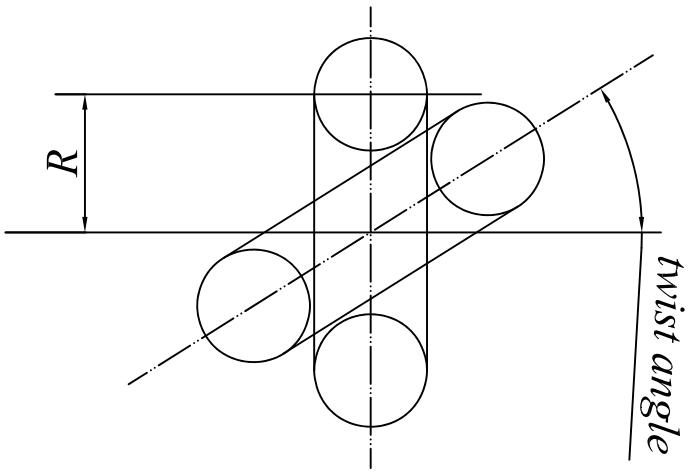


Figure 5.20: Sketch of mooring chain links subjected to torque

Hobbs and Ridge (2005) described the contact region between mooring chains with increasing of twist angle as follows. At the beginning, the chain twist angles are at 0 degrees to each other, and the contact region is circular. With the increasing twist angle, the contact region becomes elliptical shaped. As the rotation of the mooring chain increases, the contact region separates into two distinct patches, and a gap appears at the original contact point. The contact region

then moves further from the bend parts to the straight parts of mooring chains. In the end, a lock-up situation occurs, with contact on the straight parts of the mooring chains, and the theoretical maximum twist angles are close to 30 degrees.

However, for the cases that tensioned mooring chain links are rotated by the ropes during the operation, the gaps between the inner surfaces of the crown sections are not allowed, and the maximum twist angles are close to 20 degrees.

Considering mooring chain links with a twist angle as shown in Figure 5.20, the torque Q between mooring chain links can be given as (Hobbs and Ridge, 2005):

$$Q = TRtan\theta tan\emptyset \tag{5.6}$$

$$\emptyset = cos^{-1}\left[2\frac{R}{D}sin^2\left(\frac{90^O-\gamma}{2}\right)\right] \tag{5.7}$$

$$\theta = sin^{-1}\left[\frac{Dsin\emptyset cos\left(\frac{90^O-\gamma}{2}\right)}{2\left(R-\frac{D}{2}cos\emptyset\right)sin\left(\frac{90^O-\gamma}{2}\right)}\right] \tag{5.8}$$

where T is tension force acting on the mooring chain links, D the nominal diameter of mooring chain link. R is the distance, as shown in Figure 5.20, γ the twist angle, as shown in Figure 5.20.

5.3.2 Finite element analysis of mooring chain links subjected to torque

A full chain and two half chains are modelled to simulate mooring chain links with twist angles, as shown in Figure 5.21. Twist angles of 5, 10, 15 and 20 degrees are considered to investigate the effect of torque induced by chain twist on the fatigue life of mooring chain links.

All of the mooring chain links in the selected mooring system are 6 inches R4 class studless chain links and they are modelled with standard dimensions considering the corrosion and wear allowance for 25 years. Mooring chain links are meshed with quadratic hexahedron with the element size of 10 to 20 mm. The tension loads are applied at End faces A, B, C and D, as shown in Figure 5.21, and the sliding of contact regions between each chain link is allowed.

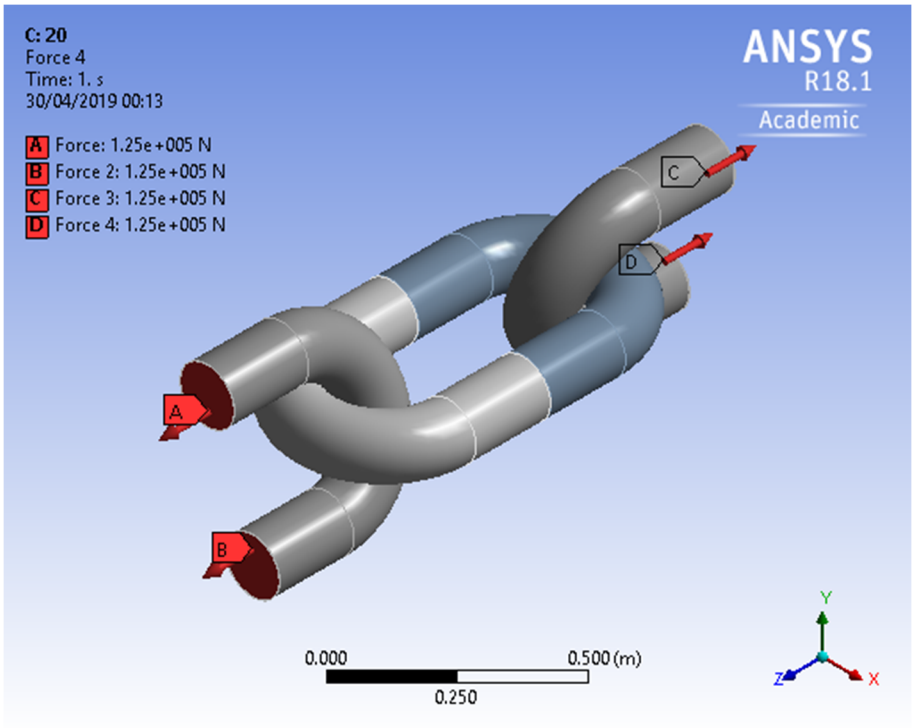


Figure 5.21: FE model and boundary conditions of mooring chain links with twist angle

5.3.3 Results and discussion

The effects of torque on the fatigue life of mooring chain with various twist angles are discussed in this section. All the fatigue lives of mooring chain links examined in the FM method considered the simplified model with the initial semi-elliptical surface crack size (a_0, c_0) of (0.5mm, 0.5mm), and the critical crack size as 12% of chain diameter.

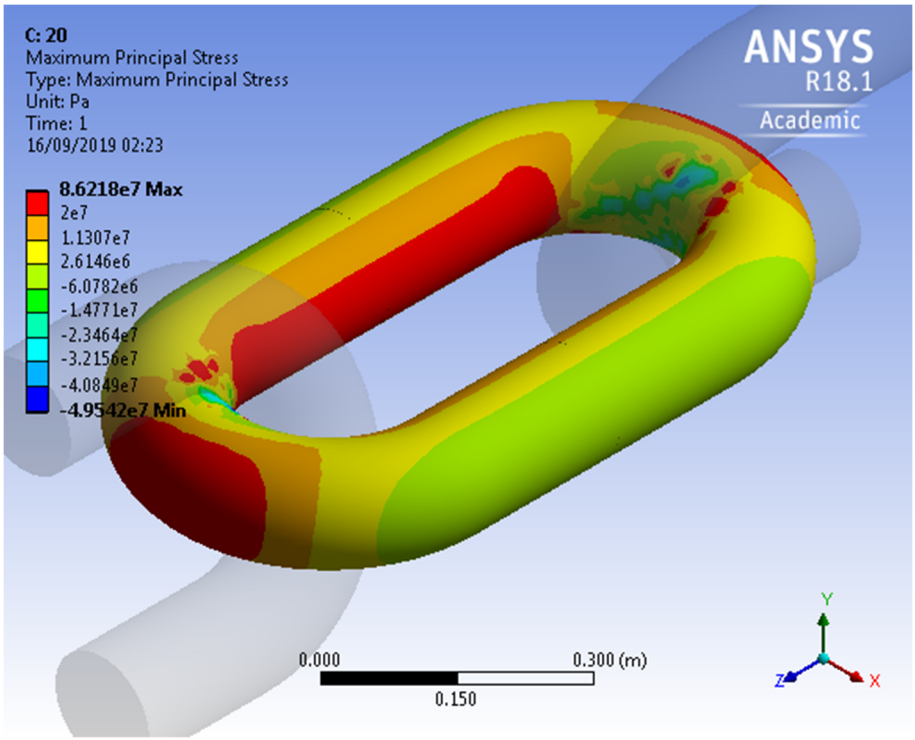
In addition, the effect of torque induced by chain twist on fatigue life of mooring chain link was presented by the ratio of fatigue life of a mooring chain link subjected to torque to that not subjected to a torque.

The maximum principal stress and normal stress of the mooring chain links with twist angles are plotted Figure 5.22. Figure 5.22 shows that the hot spot would be outside of crown section, and the largest fatigue damage would occur in this section. The SCFs of hot spots on mooring chain links with the twist angles of 5, 10, 15 and 20 are listed in Table 5.7.

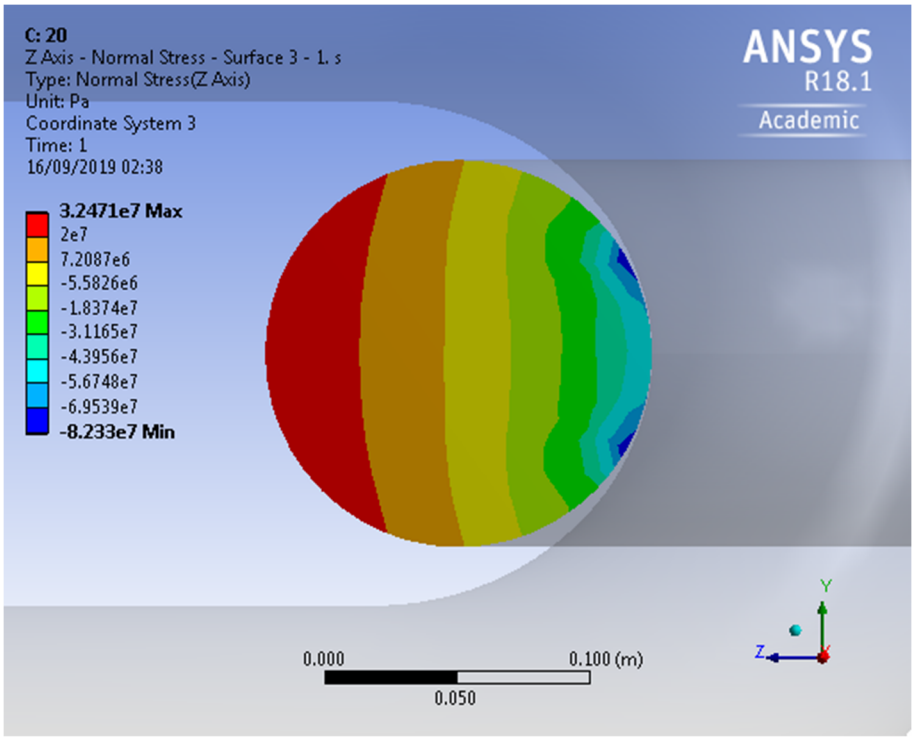
The ratios of fatigue lives of mooring chain links with various twist angles to those of common mooring chain links subjected to pure tension are plotted in Figure 5.23. Figure 5.23 shows that the ratio of fatigue lives with twist angles of 5, 10, 15 and 20 degrees are 107%, 93%, 93% and 88% of those not subjected to torque, respectively.

Table 5.7: SCFs of hot spots on mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 with friction coefficient of 0.5

	5 Degrees	10 Degrees	15 Degrees	20 Degrees
SCF	4.24	4.39	4.45	4.33
Section	$\theta_1 = 90°$	$\theta_1 = 90°$	$\theta_1 = 90°$	$\theta_1 = 90°$
Location	$\theta_2 = 270°$	$\theta_2 = 270°$	$\theta_2 = 270°$	$\theta_2 = 270°$



(a)



(b)

Figure 5.22: Stress distribution of the mooring chain link subjected to OPB constraint provided by the chain stopper: (a) maximum principal stress; (b) normal stress at the cross-section prone to fatigue

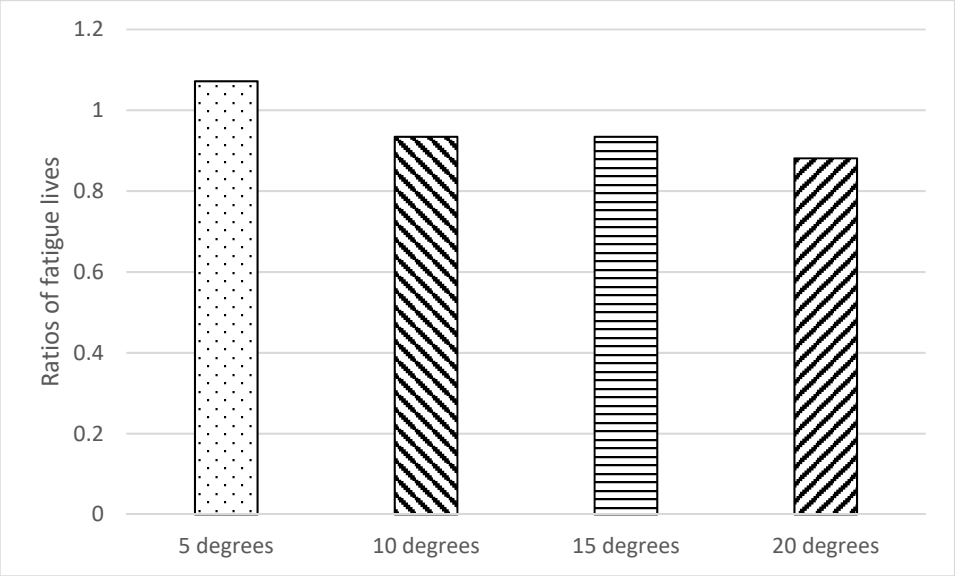


Figure 5.23: The ratios of fatigue lives of mooring chain links constraint provided by chain stoppers with the interlink angles of 1, 2, 3, 4 and 5 degrees to those not subjected to torque

5.3.4 Summary

The effects of torque induced by chain twist on the fatigue life of chain link were evaluated with the use of an FM based fatigue analysis and mooring line tensions achieved from Chapter 3. The results indicated that:

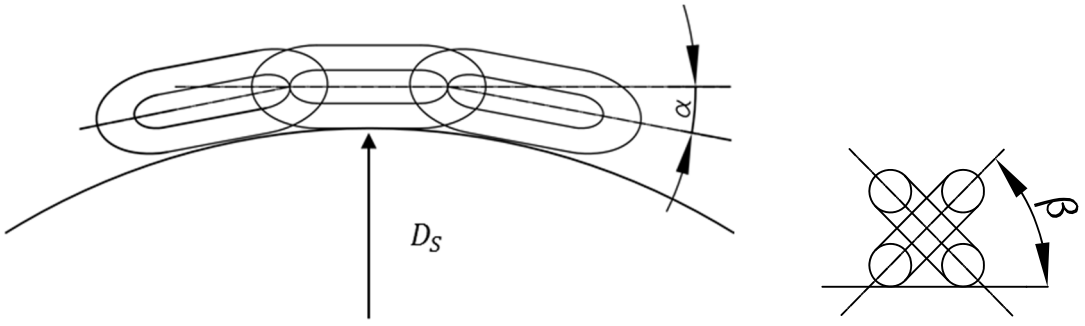
- For mooring chain links connected with a twist angle within 20 degrees, the crown section is the most critical section prone to fatigue damage. The fatigue life of mooring chain links with twist angles of 5, 10, 15 and 20 degrees are 107%, 93%, 93% and 88% of those not subjected to torque, respectively;
- When the twist angle is not larger than 5 degrees, the twist benefits to the fatigue life of mooring chain links;
- When the twist angle is between 10 to 20 degrees, the chain twist would cause the 7% to 12% decline of the fatigue life of mooring chain links.

5.4 Fracture mechanics analysis for mooring chain links tensioned over a curved surface

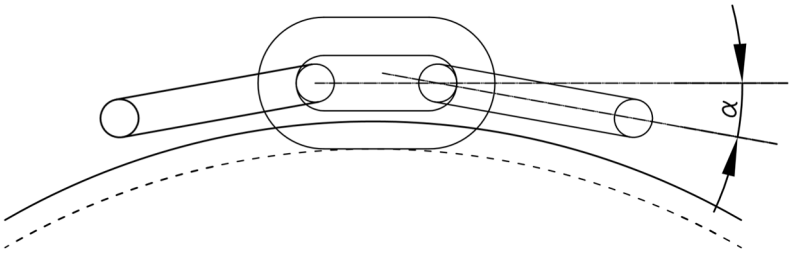
Compared with mooring chain links subjected to OPB or torque, the mechanisms of mooring chain links tensioned over curved surfaces are complex, and the study about this type of problems is relatively limited.

5.4.1 Mooring chain links tensioned over a curved surface

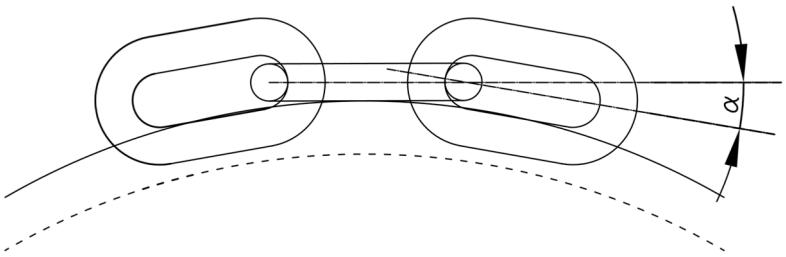
In this section, three types of curved surfaces applied in the offshore industry are illustrated, as shown in Figure 5.24, namely ungrooved surface, shallow grooved surface and deep grooved surface, respectively.



(a)



(b)



(c)

Figure 5.24: Three types of curved surfaces: (a) Ungrooved surface; (b) Shallow grooved surface; (c) Deep grooved surface

As shown in Figure 5.24, the angle between the centrelines of two adjacent chain links would is given by Angle α, and the angle between the transverse axis of a chain link and the surface is given by Angle β.

5.4.1.1 Mooring chain links tensioned over an ungrooved surface

Mooring chocks are usually welded at the decks or bulwarks to guide mooring chain links or mooring ropes for offshore platforms. For mooring chain links passing through chocks, ungrooved curved surfaces are in general provided for every mooring chain link to bear against (OCMIF, 2013). For standard mooring chain links tensioned over ungrooved surfaces, the relationship between the angle α and the angle β can be given as the function:

$$\alpha = 2arctan\frac{4}{1+\frac{D_s}{d}+2.35\sin\beta} \tag{5.9}$$

where D_s is the diameter of curved surface bearing mooring chain links, d is the nominal diameter of mooring chain link.

Figure 5.25 gives the sketch of half a mooring chain link tensioned over the ungrooved curved surface. The force T is the tension force in the mooring chain, and R is the reaction force of

surface against the chain link. As shown in Figure 5.25, the tension force T at the contact region between mooring chain links should act at an angle of $\alpha/2$ to the centreline of the mooring chain link, and this tension force applies a bending moment M at the centre of the chain links, which can be given as:

$$M = 2dTsin(\frac{\alpha}{2}) \tag{5.10}$$

Figure 5.25 also shows that as the mooring chain links lie at an angle to the curved surface, the reaction force R applies a torque about the centreline, which is resisted by the lock-up between adjacent mooring chain links. The torque Q can be calculated as:

$$Q = 1.175dTsin\beta sin(\frac{\alpha}{2}) \tag{5.11}$$

Additionally, the horizontal component of tension force T would apply a tension force F acting along the centerline of mooring chain links, which can be given as:

$$F = Tcos(\frac{\alpha}{2}) \tag{5.12}$$

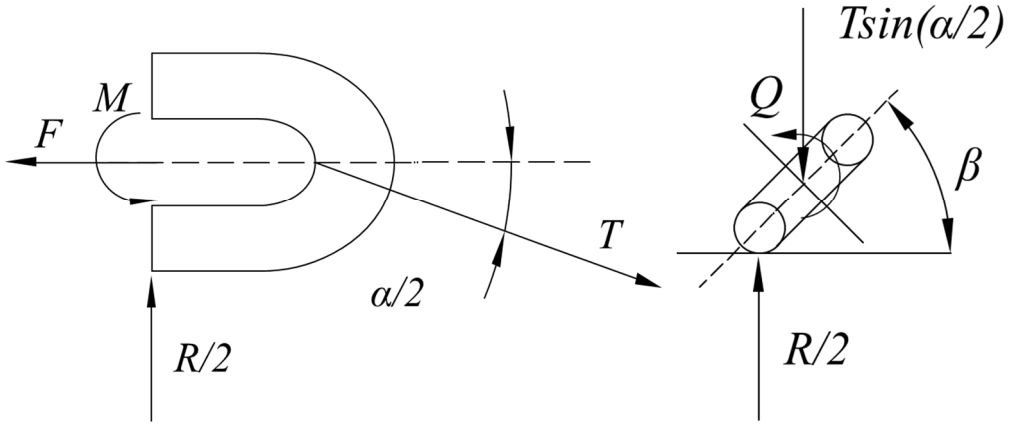


Figure 5.25: Sketch of half a mooring chain tensioned over an ungrooved surface

5.4.1.2 Mooring chain links tensioned over a shallow grooved surface

Grooved surfaces are widely adopted in mooring equipment, such as mooring chain windlasses, mooring chain sheaves, bending shoes and mooring chain hawses. For a shallow grooved surface, the depth of the groove should be smaller than $1.675d$. In this case, the upright link would contact the bottom of the groove, and the adjacent flat link is lifted away from the groove, as shown in Figure 5.24(b).

Figure 5.26 gives the sketch of half an upright link tensioned over the shallow curved surface. As shown in Figure 5.26, the tension force T applied at the contact region of the upright mooring chain link would act at an angle of α to the centreline of the upright link. The vertical component of T would induce IPB at the center of the upright mooring chain link, which can be given as:

$$M = 2dTsin\alpha \tag{5.13}$$

The horizontal component of T would induce a tension force F acting along the centreline of the upright link, which can be given as:

$$F = Tcos\alpha \tag{5.14}$$

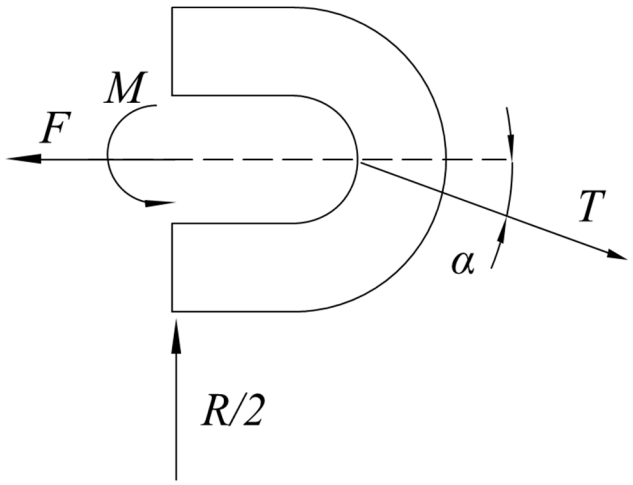


Figure 5.26: Sketch of half an upright mooring chain tensioned over a shallow grooved surface

5.4.1.3 Mooring chain links tensioned over a deep grooved surface

For a deep grooved surface, the depth of the groove should be larger than $1.675d$, in which the flat link would contact the upper surface of the groove directly, and the adjacent upright link would not touch the bottom of the groove, as shown in Figure 5.24(c).

Figure 5.27 gives the sketch of half a flat link tensioned over a deep curved surface. As shown in Figure 5.27, the tension force T applied at the contact region of the flat mooring chain link would act at an angle of α to the centerline of the flat link. The vertical component of T would induce OPB at the center of the flat mooring chain link, and the horizontal component would induce a tension force F acting along the centerline of the flat link. The OPB and tension force

at the centre of the flat mooring chain link can be approximately calculated by Equations 5-13 and 5-14, respectively.

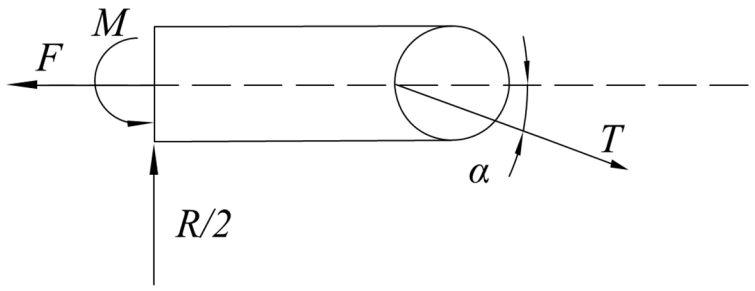


Figure 5.27: Sketch of half a flat mooring chain tensioned over a deep grooved surface

5.4.2 Finite element analysis of mooring chain link tensioned over curved surface

A series of FE analyses are performed to measure the local stresses acting on the mooring chain links tensioned over curved surfaces. Three types of curved surfaces that mooring chain links tensioned over are considered, namely, 1) an ungrooved surface; 2) a shallow grooved surface; 3) a deep grooved surface.

All of the mooring chain links in the selected mooring system are modelled with standard dimensions considering the corrosion and wear allowance for 25 years.

Mooring chain links tensioned over an ungrooved surface is modelled, as shown in Figure 5.28. The model of two half links and one full link is built, and all the chain links are supported by the curved surface. Tension forces are then applied at Ends B, C, D and E by pressure, respectively, and the upper surface of the bearing plate is fixed. The sliding behaviour of contact regions between chain links and the curved surface and each chain link are taken into account.

Three values of angle β are considered in this FE analysis: 45 degrees, 40 degrees and 35 degrees. For each value of angle β, the curved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m are considered.

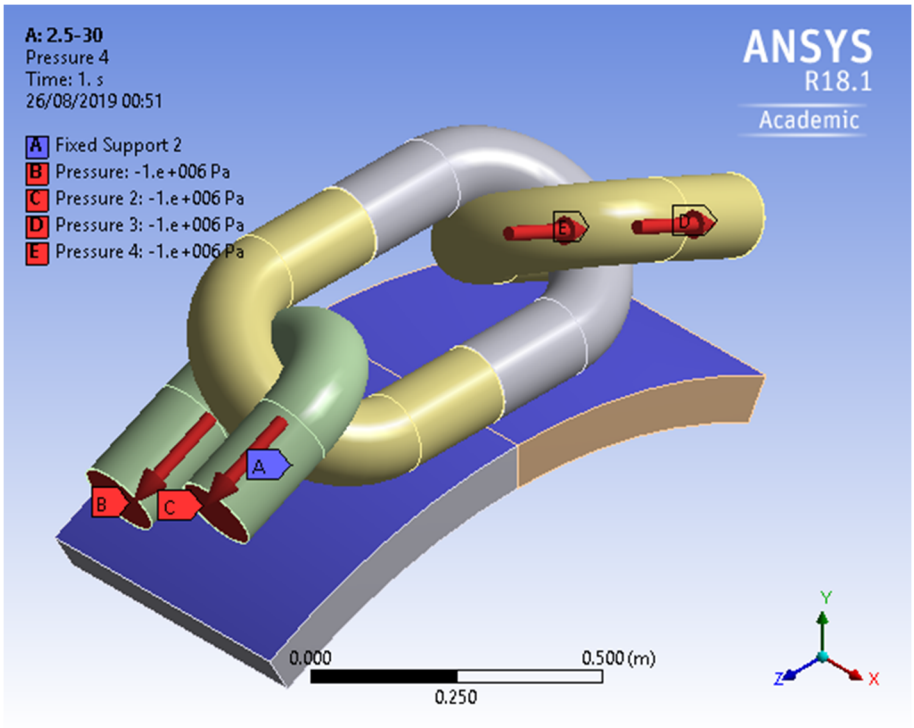


Figure 5.28: FE model and boundary conditions of mooring chain links tensioned over an ungrooved surface

For the scenario that mooring chain links tensioned over a shallow grooved surface, three mooring chain links (two half flat links and one full upright link) are modelled in the FE analysis, as shown in Figure 5.29. The upright link is supported by the fixed bottom surface of the groove, and the tension forces are applied at the ends of the adjacent flat link (Ends B, C, D and E). The sliding behaviour of contact regions between chain links and the curved surface and each chain link are taken into account. Four diameters of the grooved surface (the diameter of the bottom face) are considered as 2.5 m, 3.0 m, 3.5 m and 4.0 m.

Two half upright links and one full flat link are modelled for the scenario that mooring chain links tensioned over a deep grooved surface, as shown in Figure 5.30. The flat link is supported by the fixed upper surface of the deep groove, and the tension forces are applied at the Ends of adjacent upright mooring link (Ends B, C, D and E) by pressure. The sliding behaviour of contact regions between chain links and the curved surface, and each chain link are taken into account. Four diameters of the deep grooved surfaces (the diameter of the upper face) are considered as 2.5 m, 3.0 m, 3.5 m and 4.0 m as well.

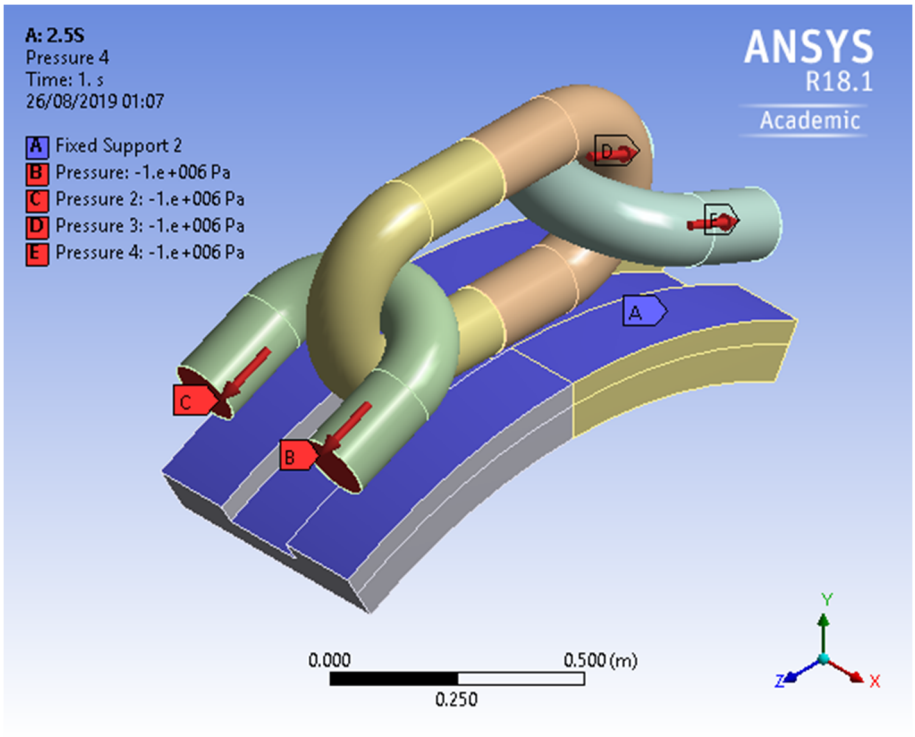


Figure 5.29: FE model and boundary conditions of mooring chain links tensioned over a shallow surface

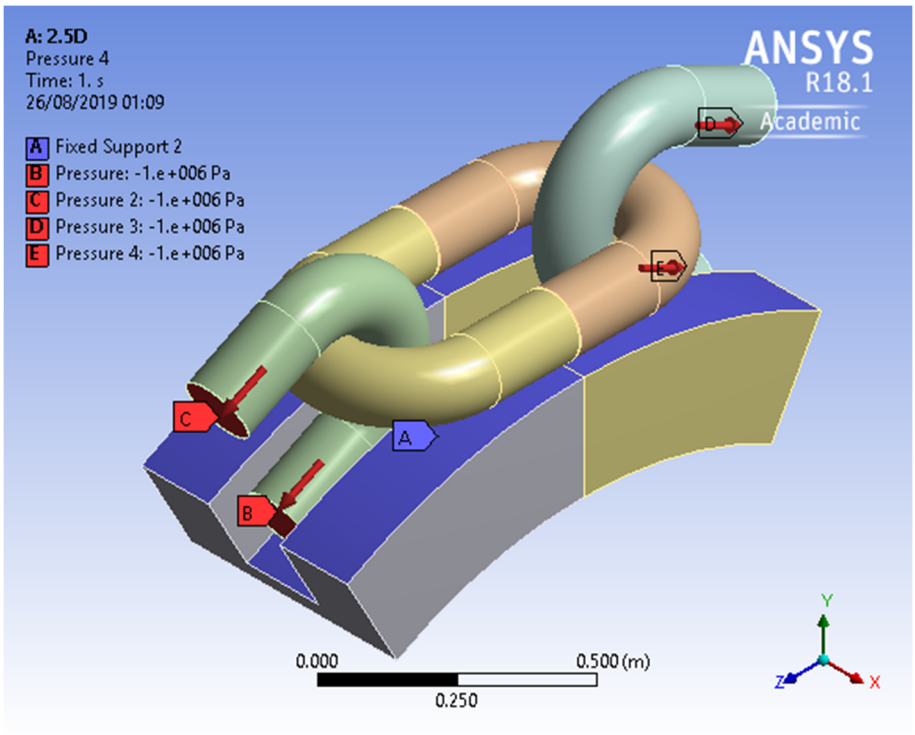


Figure 5.30: FE model and boundary conditions of mooring chain links tensioned over a shallow grooved surface

5.4.3 Results and discussion

The effects of ungrooved surfaces, shallow grooved surfaces and deep grooved surfaces bearing against mooring chain links on the fatigue life of mooring chain links are discussed in this section, respectively. All the fatigue lives of mooring chain links examined in FM method considered the simplified model with the initial semi-elliptical surface crack size (a_0, c_0) of (0.5mm, 0.5mm), and the critical crack size as 12% of chain diameter.

In addition, the effects of curved surfaces on fatigue lives of mooring chain links are presented by the ratio of fatigue of a mooring chain link tensioned over a curved surface to that not tensioned over a curved surface.

5.4.3.1 Mooring chain links tensioned over an ungrooved surface

The maximum principal stress and normal stress at the cross-section prone to fatigue of the mooring chain links tensioned over an ungrooved surface is shown in Figure 5.31. Figure 5.31 shows that the hot spot is located at the outside surface of the weld section of the chain link laying on the bearing plate, and the largest fatigue damage would occur at this section. The SCFs and locations for hot spots at links laying on ungrooved surfaces with diameters of 2.5m, 3.0 m, 3.5 m and 4.0 m with $\beta = 45°$, 40°,and 30° are listed in Table 5.8 to 5.10, respectively.

Table 5.8: SCFs of hot spots on mooring chain links laying on ungrooved surfaces with diameters of 2.5m, 3.0 m, 3.5 m and 4.0 m with $\beta = 45°$

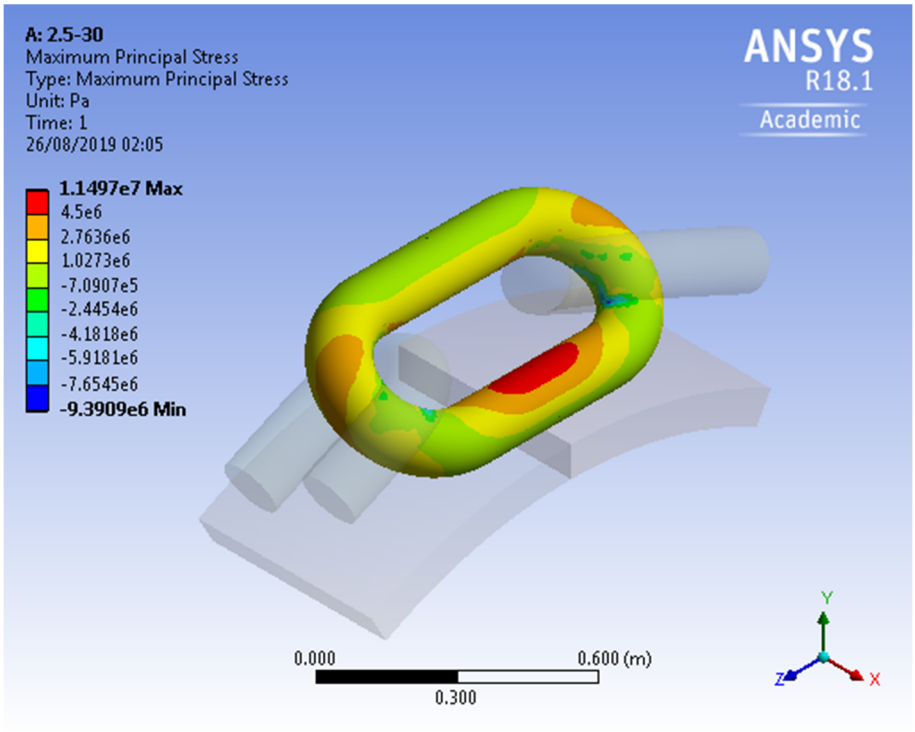
	Diameter = 2.5 m	Diameter = 3.0 m	Diameter = 3.5 m	Diameter = 4.0 m
SCF	8.31	7.12	6.26	5.61
Section	Weld section	Weld section	Weld section	Weld section
Location	$\theta_2 = 45°$	$\theta_2 = 45°$	$\theta_2 = 45°$	$\theta_2 = 45°$

Table 5.9: SCFs of hot spots on mooring chain links laying on ungrooved surfaces with diameters of 2.5m, 3.0 m, 3.5 m and 4.0 m with $\beta = 40°$

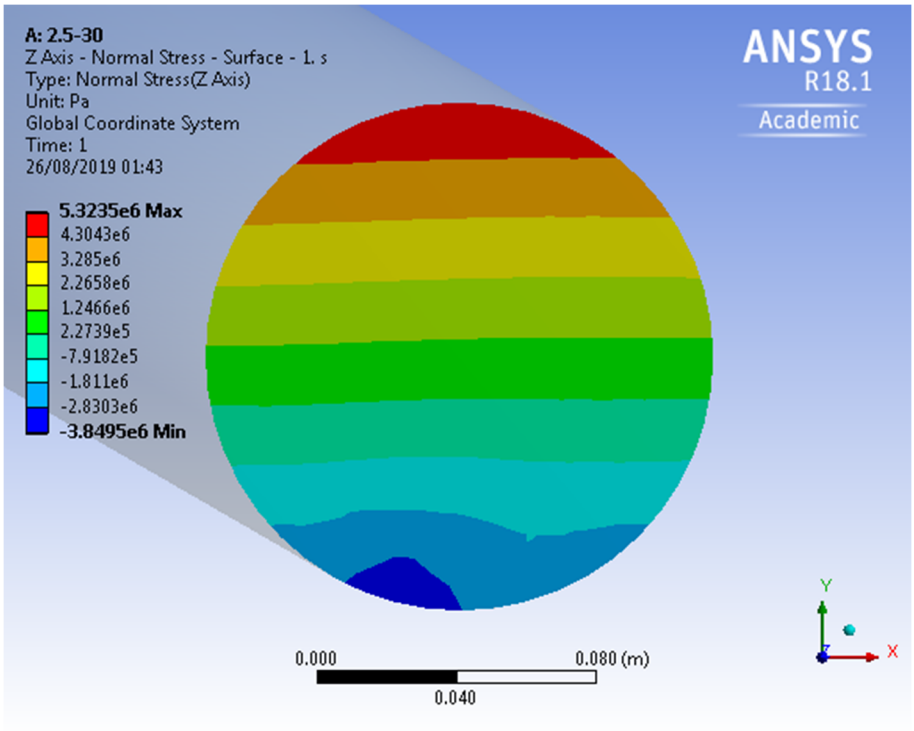
	Diameter = 2.5 m	Diameter = 3.0 m	Diameter = 3.5 m	Diameter = 4.0 m
SCF	7.48	6.71	5.80	5.29
Section	Weld section	Weld section	Weld section	Weld section
Location	$\theta_2 = 40°$	$\theta_2 = 40°$	$\theta_2 = 40°$	$\theta_2 = 40°$

Table 5.10: SCFs of hot spots on mooring chain links laying on ungrooved surfaces with diameters of 2.5m, 3.0 m, 3.5 m and 4.0 m with $\beta = 35°$

	Diameter = 2.5 m	Diameter = 3.0 m	Diameter = 3.5 m	Diameter = 4.0 m
SCF	6.03	5.53	5.05	4.46
Section	Weld section	Weld section	Weld section	Weld section
Location	$\theta_2 = 35°$	$\theta_2 = 35°$	$\theta_2 = 35°$	$\theta_2 = 35°$



(a)



(b)

Figure 5.31: Stresses of mooring chain link tensioned over an ungrooved surface: (a) Maximum principal stress; (b) normal stress at the critical location prone to fatigue

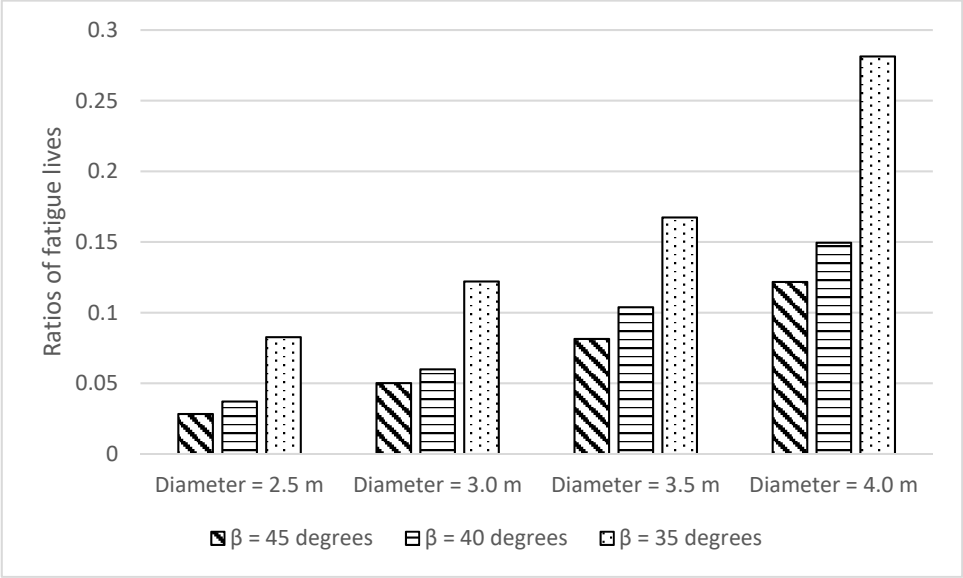


Figure 5.32: The ratios of fatigue lives of weld sections of mooring chain links tensioned over ungrooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m to those not tensioned over a curved surface

The ratios of fatigue lives of weld sections of mooring chain links tensioned over an ungrooved surface with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m considering different β angles calculated by the FM method to those of the chain link not laying on a curved surface are plotted in Figure 5.32. Figure 5.32 shows that fatigue lives of weld sections of mooring chain links tensioned over ungrooved surfaces are sensitive to the Angle β and diameter of the curved surface. The fatigue lives of weld sections tensioned over an ungrooved surface are approximately 3% to 12%, 4% to 15% and 8% to 28% of those of the common chain link not tensioned over a curved surface for considering $\beta = 45°$, $40°$,and $30°$, respectively. In addition, the fatigue lives of mooring chain links would drop obviously with the decrease of the diameter of the curved surface. The fatigue lives of weld sections of mooring chain links tensioned over ungrooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m are approximately 3% to 8%, 5% to 12%, 8% to 17% and 12% to 28% of those of the common chain link not tensioned over a curved surface, respectively.

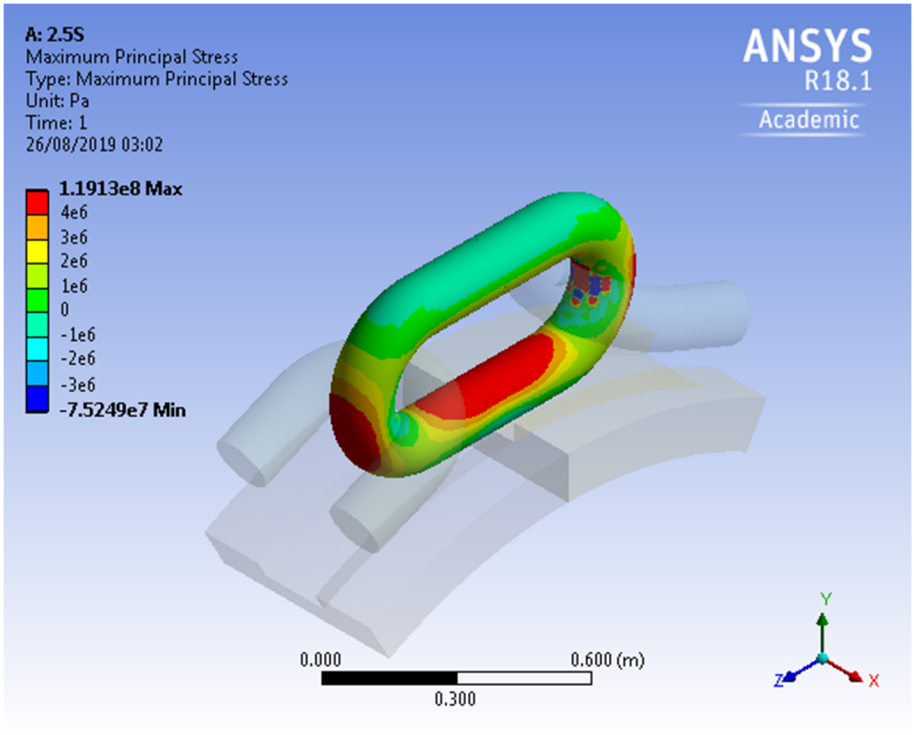
5.4.3.2 Mooring chain links tensioned over a shallow grooved surface

The maximum principal stress and normal stress at the cross-section prone to fatigue of the mooring chain links tensioned over a shallow grooved surface is shown in Figure 5.33. Figure 5.33 shows that the hot spot is located at the inner surface of the weld section of mooring chain link laying on the bearing plate, and the largest fatigue damage would occur at this section. The SCFs and locations of the hot spots at links laying on shallow grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m are listed in Table 5.11, respectively.

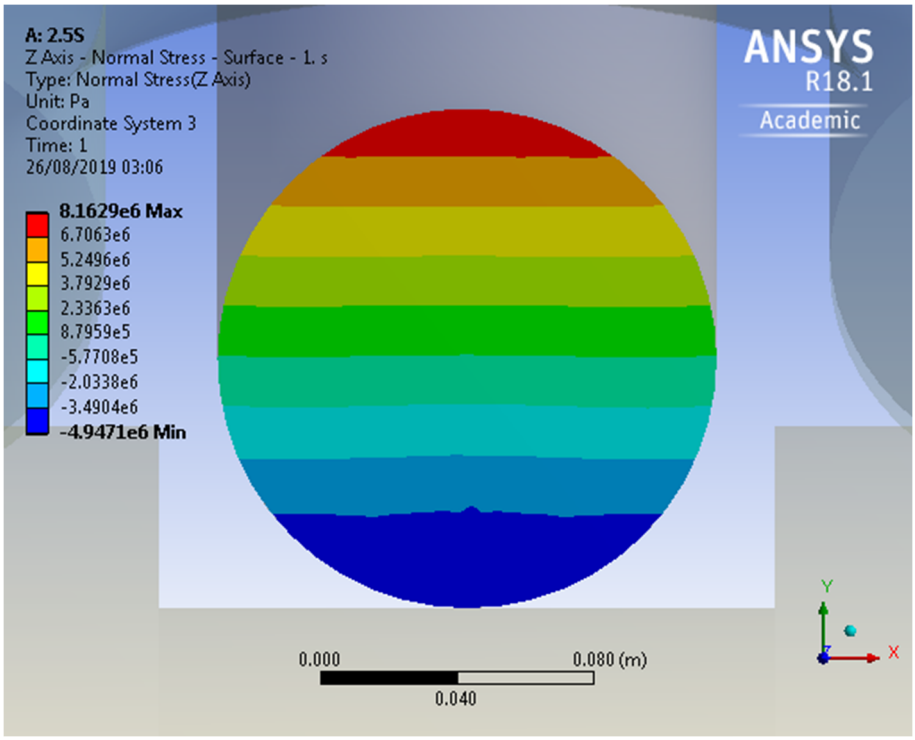
The ratios of fatigue lives of crown sections of mooring chain links laying on shallow grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m calculated by the FM method to those of the chain link not lying on a curved surface are plotted in Figure 5.34. Figure 5.34 shows that the fatigue life of mooring chain links tensioned over shallow grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m is 3%, 5%, 7% and 10% of that of the mooring chain link not tensioned over a curved surface, respectively, which means that the effects of shallow grooved surface bearing mooring chain links on the fatigue of mooring chain links are significant. In addition, the fatigue lives of mooring chain links would drop with the decrease of the diameter of the shallow grooved surface.

Table 5.11: SCFs of hot spots on mooring chain links laying on shallow grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m

	Diameter = 2.5 m	Diameter = 3.0 m	Diameter = 3.5 m	Diameter = 4.0 m
SCF	8.16	7.04	6.36	5.90
Section	Weld section	Weld section	Weld section	Weld section
Location	$\theta_2 = 90°$	$\theta_2 = 90°$	$\theta_2 = 90°$	$\theta_2 = 90°$



(a)



(b)

Figure 5.33: Stresses of mooring chain link tensioned over a shallow grooved surface: (a) Maximum principal stress; (b) normal stress at the critical location prone to fatigue

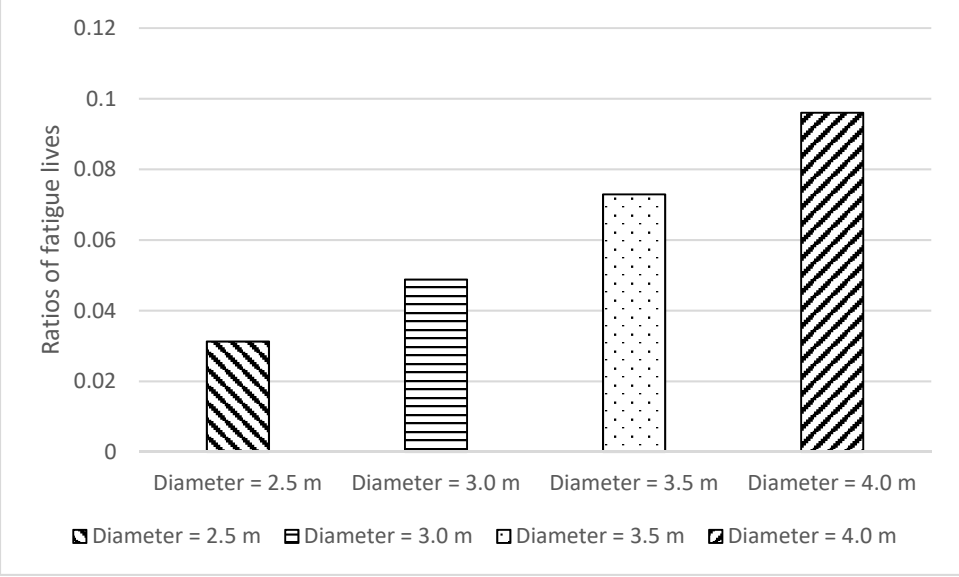


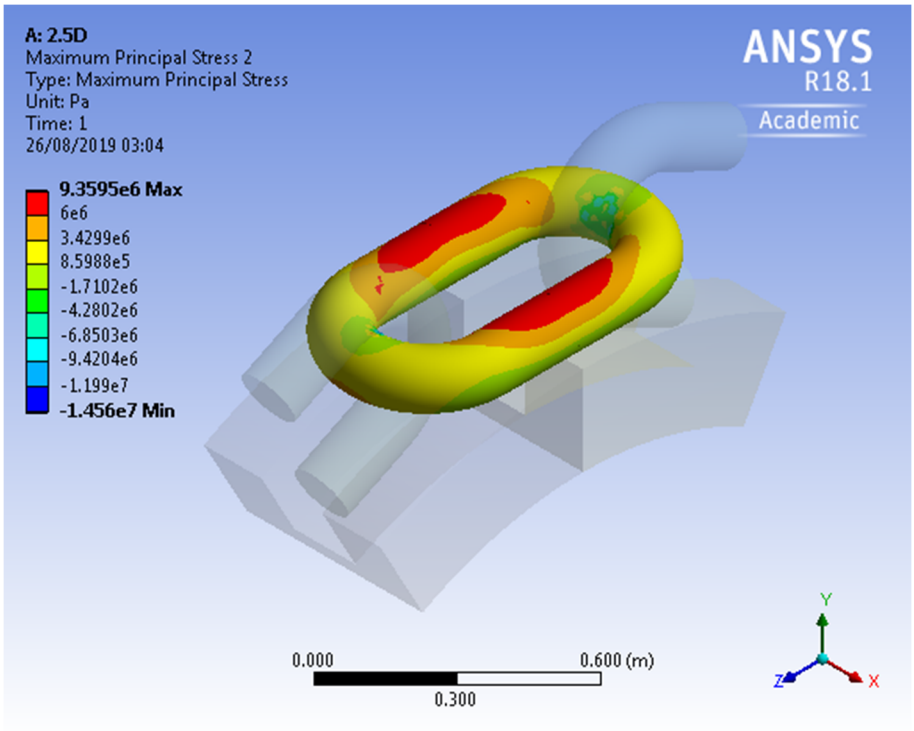
Figure 5.34: The ratios of fatigue lives of weld sections of mooring chain links tensioned over shallow groove surface with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m to those not tensioned over a curved surface

5.4.3.3 Mooring chain links tensioned over a deep grooved surface

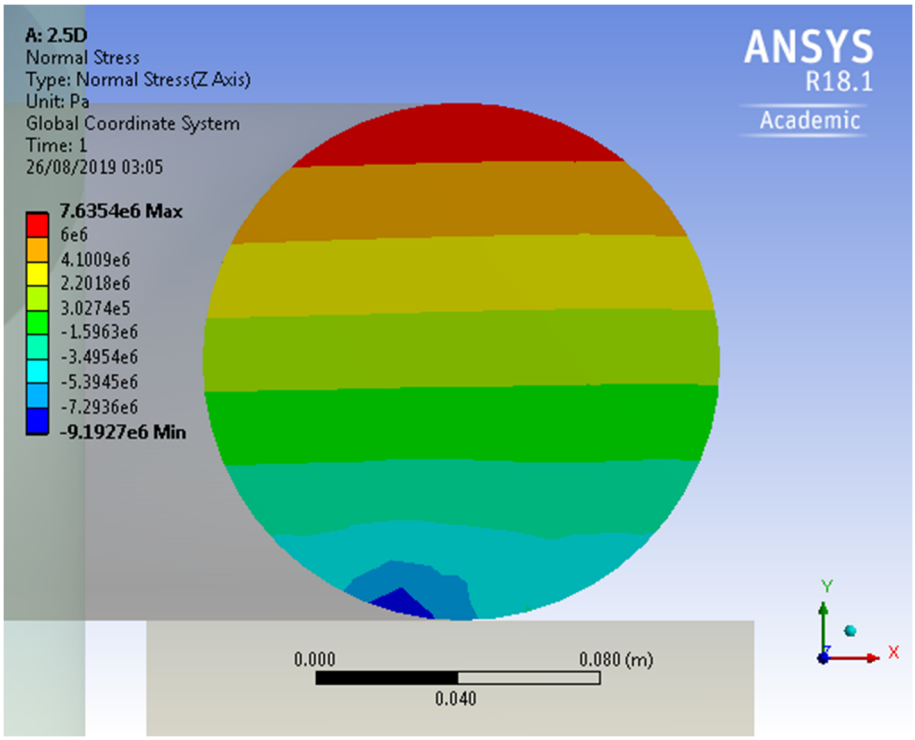
The maximum principal stress and normal stress at the cross-section prone to fatigue of the mooring chain links tensioned over a deep grooved surface is shown in Figure 5.35. Figure 5.35 shows that the hot spot is located at the upper surface of the weld section of the mooring chain link laying on the bearing plate, and the largest fatigue damage would occur at this section. The SCFs and locations for hot spots at links laying on deep grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m are listed in Table 5.12, respectively.

Table 5.12: SCFs of hot spots on mooring chain links laying on deep grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m

	Diameter = 2.5 m	Diameter = 3.0 m	Diameter = 3.5 m	Diameter = 4.0 m
SCF	7.64	6.21	5.25	5.05
Section	Weld section	Weld section	Weld section	Weld section
Location	$\theta_2 = 0°$	$\theta_2 = 0°$	$\theta_2 = 0°$	$\theta_2 = 0°$



(a)



(b)

Figure 5.35: Stresses of mooring chain link tensioned over a deep grooved surface: (a) Maximum principal stress; (b) normal stress at the critical location prone to fatigue

The ratios of fatigue lives of crown sections of mooring chain links laying on deep grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m calculated by the FM method to those of the chain link not laying on a curved surface are plotted in Figure 5.36. Figure 5.36 shows fatigue lives of mooring chain links tensioned over deep grooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m are 4%, 8%, 15% and 17% of those of the mooring chain links not tensioned over a curved surface, respectively, which means that the effects of deep grooved surface bearing mooring chain links on the fatigue of mooring chain links are significant. In addition, the fatigue life of mooring chain links would drop with the decrease of the diameter of the deep grooved surface.

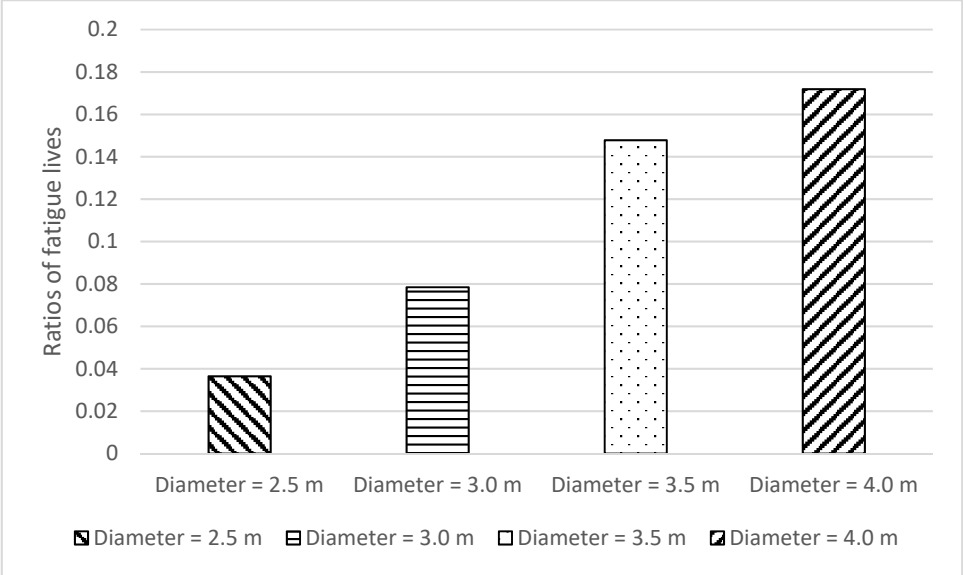


Figure 5.36: The ratios of fatigue lives of weld sections of mooring chain links tensioned over deep groove surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m to those not tensioned over a curved surface

5.4.4 Summary

The mechanism of mooring chain links tensioned over three types of curved surfaces, namely ungrooved surface, shallow grooved surface and deep grooved surface, was investigated by the developed FM based mooring fatigue assessment approach and mooring line tensions achieved from Chapter 3. The results show that:

- The effects of being tensioned over a curved surface on the fatigue lives of mooring chain links are in general significant;
- For mooring chain links tensioned over a curved surface, the weld sections are the most critical sections prone to fatigue damage;
- With increasing diameter of the curved surface, the fatigue life of mooring chain links increases. The fatigue life of mooring chain links drops obviously with the decrease of the diameter of the curved surface.
- The fatigue life of weld sections of mooring chain links tensioned over ungrooved surfaces with diameters of 2.5 m, 3.0 m, 3.5 m and 4.0 m are approximately 3% to 8%, 5% to 12%, 8% to 17% and 12% to 28% of those of the common chain link not tensioned over a curved surface, respectively. The ratios of fatigue lives of mooring chain links tensioned over curved surfaces with diameters from 2.5 m to 4.0 m to those not tensioned over a curved

surface are 3% to 10% for the shallow grooved surfaces, 4% to 17% for the deep grooved surface.

- For mooring chain links tensioned over an ungrooved surface, the decrease of the angle between the transverse axis of the mooring chain link and a curved surface (Angle β) would diminish the influence of curved surface on the fatigue life reduction of chain links. The fatigue lives of weld sections tensioned over an ungrooved surface are approximately 3% to 12%, 4% to 15% and 8% to 28% of those of the common chain link not tensioned over a curved surface for considering $\beta = 45°$, $40°$,and $30°$, respectively.

5.5 Summary

The developed FM based mooring fatigue assessment approach is then applied for mechanism investigation on mooring chain links subjected to out-of-plane bending (OPB), mooring chain links subjected to torque, and mooring chain links tensioned over a curved surface. The results show that:

- Fatigue lives of mooring chain links are in general decreased significantly due to effects of OPB and curved surface;
- In contrast, the effect of torque induced by the chain twist on fatigue lives of mooring chain links is not obvious.

Chapter 6. Effects of the Load Combination Method on a Fracture Mechanics Based Mooring Fatigue Assessment

6.1 Introduction

In the design phase, most frequency-domain fatigue analyses of offshore mooring systems subjected to Gaussian load processes are performed using the Palmgren-Miner's rule and T-N/S-N curves. These practices have been widely accepted by offshore design codes, i.e. DNVGL OS E301(2015), API RP 2SK (2008) and ISO 19901-7 (2013), where narrow-band (Bendat, 1958) and wide-band load combination methods are suggested for predicting the combined loads induced by low-frequency (LF) and wave-frequency (WF) motions in mooring fatigue analyses of offshore mooring systems.

An investigation on the effects of load combination methods on the fatigue life of mooring chain links predicted by the FM based mooring fatigue assessment approach is made in this chapter. Low-frequency (LF) and wave-frequency (WF) tensions of mooring lines are predicted by a frequency-domain analysis taking into account environmental effects including wind, wave and current as presented in Chapter 3. The LF and WF load processes are regarded as two random processes. The narrow-band method, general wide-band methods (Dirlik method and Tovo and Benasciutti method), and dual narrow-band methods (Jiao and Moan method, Fu and Cebon method and modified Fu and Cebon method) are used for predicting the combined load induced by LF and WF motions in the FM analysis. A comparison between mooring fatigue lives predicted by the FM analysis using these load combination methods is performed.

6.2 Combination of LF and WF tensions

Processes of LF and WF mooring line tensions are regarded herein as two independent narrow-band Gaussian load processes, namely $X_L(t)$ and $X_W(t)$, in which $X_L(t)$ is a low-frequency process and $X_W(t)$ is a high frequency process. $X(t)$ is defined as the combined process of $X_L(t)$ and $X_W(t)$ and it represents the dynamic mooring line tension process. In this section, the narrow-band method, general wide-band methods, and dual narrow-band methods are briefly introduced to explain how to achieve the $X(t)$, the combined process of $X_L(t)$ and $X_W(t)$.

6.2.1 Narrow-band method

The narrow-band method (Bendat, 1958) was developed based on the work of Rice (1954) and it estimates fatigue damage correlating with the spectral density function of the load process. This method is generally conservative and may significantly overestimate the actual fatigue damage (API RP 2SK, 2008) when the Palmgren-Miner's rule and T-N/S-N curves are used to predict fatigue damage.

In this method, the combination of the LF and WF load processes, $X(t)$, is assumed to be a narrow-band Gaussian process given by:

$$X(t) = X_L(t) + X_W(t) \tag{6.1}$$

The spectral density function $G(f)$ of $X(t)$ is then expressed as:

$$G(f) = G_L(f) + G_W(f) \tag{6.2}$$

where f is the frequency in hertz, $G_L(f)$ and $G_W(f)$ are spectral density functions of load processes $X_L(t)$ and $X_W(t)$, respectively.

As $X(t)$ is a narrow-band Gaussian process, the nth order spectral moment of $X(t)$, m_n can be characterised by the spectral density function $G(f)$ as:

$$m_n = \int_0^\infty f^n G(f) df \approx v_0^n \, m_0 \tag{6.3}$$

where v_0 is the mean zero up-crossing frequency of $X(t)$. The amplitude of cycles in $X(t)$, X_a, then follows the Rayleigh distribution. The probability density function of X_a is thus written as:

$$f_{X_a}(x_a) = \frac{x_a}{\sigma^2} e^{\left(\frac{-x_a^2}{2\sigma^2}\right)} \tag{6.4}$$

where σ is the standard deviation of $X(t)$, and it can be calculated as:

$$\sigma = \sqrt{m_0} = \sqrt{\sigma_L^2 + \sigma_W^2} \tag{6.5}$$

where σ_L and σ_W are the standard deviations of $X_L(t)$ and $X_W(t)$, respectively.

Thus, the mean zero up-crossing frequency of $X(t)$, v_0, can be formulated as:

$$v_0 = \sqrt{\frac{m_2}{m_0}} \approx \sqrt{\lambda_L v_{0,L}^2 + \lambda_W v_{0,W}^2} \tag{6.6}$$

where $v_{0,L}$ and $v_{0,W}$ are the mean zero up-crossing frequencies of $X_L(t)$ and $X_W(t)$, respectively. λ_L and λ_W are given by:

$$\lambda_L = \frac{\sigma_L^2}{\sigma_L^2+\sigma_W^2} \tag{6.7}$$

$$\lambda_W = \frac{\sigma_W^2}{\sigma_L^2+\sigma_W^2} \tag{6.8}$$

6.2.2 General wide-band methods

Two general wide-band methods, including Dirlik method (Dirlik, 1985) and Tovo and Benasciutti method (Benasciutti and Tovo, 2005) are described herein.

6.2.2.1 Dirlik method

In this method, the frequency of the combined load process $X(t)$ is considered as the peak frequency of $X(t)$, namely v_p, which is given by:

$$v_p = \sqrt{\frac{m_4}{m_2}} \tag{6.9}$$

The probability density function of the amplitude of cycles in $X(t)$, $f_{X_a}(x_a)$, is approximated as the sum of an exponential distribution function and two Rayleigh distribution functions as:

$$f_{X_a}(x_a) = \frac{1}{\sigma}\left[\frac{D_1}{Q}e^{-\frac{Z}{Q}} + \frac{D_1 Z}{R^2}e^{-\frac{Z^2}{2R^2}} + D_3 Z e^{-\frac{Z^2}{2}}\right] \tag{6.10}$$

where:

$$Z = \frac{x_a}{\sigma} \tag{6.11}$$

$$D_1 = \frac{2(x_m-\alpha_2^2)}{1+\alpha_2^2} \tag{6.12}$$

$$D_2 = \frac{1-\alpha_2-D_1+D_1^2}{1-R} \tag{6.13}$$

$$D_3 = 1 - D_1 - D_2 \tag{6.14}$$

$$x_m = \frac{m_1}{m_0}\left(\frac{m_2}{m_4}\right)^{0.5} \tag{6.15}$$

$$Q = \frac{1.25(\alpha_2-D_3-D_2 R)}{D_1} \tag{6.16}$$

$$R = \frac{\alpha_2 - x_m - D_1^2}{1 - \alpha_2 - D_1 + D_1^2} \tag{6.17}$$

where α_2 is the bandwidth of load spectrum and it is defined as:

$$\alpha_2 = \frac{m_2}{\sqrt{m_0 m_4}} \tag{6.18}$$

6.2.2.2 Tovo and Benasciutti method

In this method, the fatigue damage induced by the combined load process $X(t)$ is calculated by:

$$D_X = wD_{NB} + (1 - w)D_{RC} \tag{6.19}$$

where w is the weight factor, D_{NB} is the fatigue damage due to $X(t)$ estimated by the narrow-band method, D_{RC} is the range counting damage intensity due to $X(t)$ and it can be predicted by an approximate formula (Madsen et al., 1986) as:

$$D_{RC} = D_{NB}\, \alpha_2^{m-1} \tag{6.20}$$

where m is the fatigue strength exponent of an S-N curve.

The weight factor w can be approximated using a fitting formula:

$$w \cong \frac{(\alpha_1 - \alpha_2)\left[1.112(1 + \alpha_1\alpha_2 - \alpha_1 - \alpha_2)e^{2.11\alpha_2} + \alpha_1 - \alpha_2\right]}{(\alpha_2 - 1)^2} \tag{6.21}$$

where α_1 is the bandwidth of load spectrum and it is given by:

$$\alpha_1 = \frac{m_1}{\sqrt{m_0 m_2}} \tag{6.22}$$

6.2.3 Dual narrow-band methods

A special case of wide-band spectrum is called dual narrow-band spectrum, and its spectral density function is the summation of two narrow-band frequency components. This type of the spectrum is characterised by two well-defined loading frequencies, and it is a typical example of the load responses observed in offshore mooring systems.

Dual narrow-band methods including Jiao and Moan method (Jiao and Moan, 1990), Fu and Cebon method (Fu and Cebon, 2000), modified Fu and Cebon method (Benasciutti and Tovo, 2007) are described herein.

6.2.3.1 Jiao and Moan method

Let $X^*(t)$ be the normalised process of $X(t)$ where the variance of $X^*(t)$ is 1.0, and $X^*(t)$ is the combination of $X_L^*(t)$ and $X_W^*(t)$ that are the corresponding modified load processes of $X_L(t)$ and $X_W(t)$. The fatigue damage D_X due to $X(t)$ can be approximated as

$$D_X = \frac{D_X^*}{D_{NB}^*} D_{NB} \tag{6.23}$$

where D_{NB}^* is the fatigue damage due to $X^*(t)$ and it is calculated by the narrow-band method. D_X^* is the fatigue damage induced by $X^*(t)$. Based on the work of Madsen (1982), D_X^* is given by

$$D_X^* = D_P^* + D_W^* \tag{6.24}$$

where D_W^* the fatigue damage induced by $X_W^*(t)$ and it is calculated by the narrow-band method. D_P^* is the fatigue damage induced by the load process $P^*(t)$ which is the sum of $X_L^*(t)$ and the envelope of $X_W^*(t)$.

The mean zero up-crossing frequency of $P^*(t)$ is given by Toro (1984) as:

$$\upsilon_{0,p} = \lambda_L \upsilon_{0,L} \sqrt{1 + \frac{\lambda_W}{\lambda_L} \left(\frac{\upsilon_{0,W}}{\upsilon_{0,L}} \delta\right)^2} \tag{6.25}$$

where λ_L and λ_W are variances of $X_L^*(t)$ and $X_W^*(t)$, $\upsilon_{0,L}$ and $\upsilon_{0,W}$ are mean zero up-crossing frequencies of $X_L^*(t)$ and $X_W^*(t)$, and δ is the bandwidth parameter of $X_W^*(t)$.

The amplitude process of $P^*(t)$ is considered as the sum of the envelopes of $X_L^*(t)$ and $X_W^*(t)$ and the probability density function of the amplitude of cycles in $P^*(t)$ is given by (Jiao and Moan, 1990):

$$f_{P_a^*}(p_a^*) = (\lambda_L - \sqrt{\lambda_L \lambda_W}) p_a^* e^{-\left(\frac{p_a^{*2}}{2\lambda_L}\right)} + \sqrt{2\pi \lambda_L \lambda_W} (p_a^{*2} - 1) e^{-\left(\frac{p_a^{*2}}{2}\right)} \tag{6.26}$$

6.2.3.2 Fu and Cebon method

Fatigue damage due to the combined process of $X(t)$, D_X, can be divided into two individual components as:

$$D_X = D_G + D_S \tag{6.27}$$

where D_G is the fatigue damage induced by the 'large cycles' load process $X_G(t)$ in $X(t)$, and D_S is the fatigue damage induced by the 'small cycles' load process $X_S(t)$ in $X(t)$.

The mean zero up-crossing frequency of $X_G(t)$, $v_{0,G}$, can be approximated by the mean zero up-crossing frequency of $X_L(t)$, $v_{0,L}$. The amplitude process of $X_G(t)$ is considered as the sum of the envelopes of $X_L(t)$ and $X_W(t)$ and the probability density function of the amplitude of cycles in $X_G(t)$ then can be expressed as:

$$f_{X_{G,a}}(x_{G,a}) = \frac{1}{m_{0,L}m_{0,W}} e^{-\frac{x_{G,a}^2}{2m_{0,W}^2}} \int_0^\infty (x_{G,a}y - y^2)\, e^{-(\frac{1}{2m_{0,L}}+\frac{1}{2m_{0,W}})y^2+\frac{1}{m_{0,W}}x_{G,a}y} dy \quad (6.28)$$

where $m_{0,L}$ and $m_{0,W}$ are the variance of $X_L(t)$ and $X_W(t)$.

The amplitude process of $X_S(t)$ is assumed to be the envelope of $X_W(t)$ and the amplitude of cycles in $X_S(t)$ follows the Rayleigh distribution since $X_W(t)$ is a narrow-band Gaussian process. The mean zero up-crossing frequency of $X_S(t)$, $v_{0,S}$, is considered as:

$$v_{0,S} = v_{0,W} - v_{0,G} \quad (6.29)$$

where $v_{0,W}$ is the mean zero up-crossing frequency of $X_W(t)$.

6.2.3.3 Modified Fu and Cebon method

Benasciutti and Tovo (2007) proposed modification for the Fu and Cebon method (Fu and Cebon, 2000). In the modification, the mean zero up-crossing frequency of the 'large cycles' load process $X_G(t)$, $v_{0,G}$, is replaced by

$$v_{0,G} = \lambda_L v_{0,L} \sqrt{1 + \frac{\lambda_W}{\lambda_L}(\frac{v_{0,W}}{v_{0,L}}\delta)^2} \quad (6.30)$$

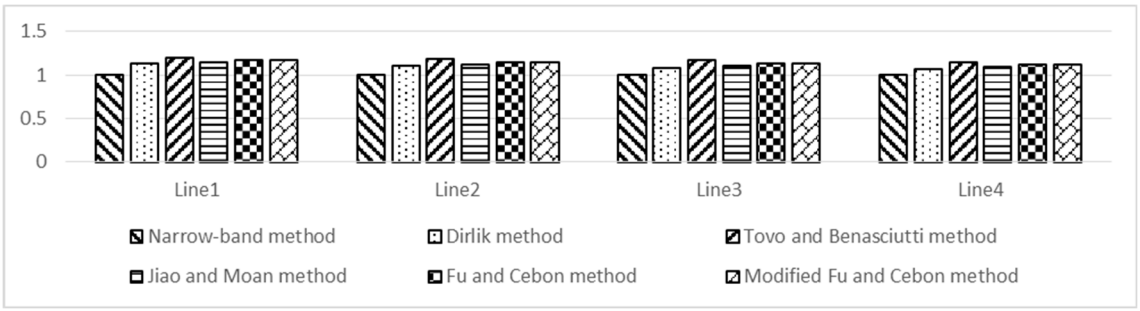
6.3 Results and discussion

The effects of load combination method on fatigue life of mooring chain are discussed separately in this section. All the fatigue lives of mooring chain links examined in the FM method considered the simplified model with the initial semi-elliptical surface crack size (a_0, c_0) of (0.5mm, 0.5mm). The critical crack depths are set as 12% of the chain diameter at weld sections, 30% of the chain diameter at bend section and 15% of the chain diameter at crown section as Mathisen and Larsen (2004) recommended, as mentioned in Chapter 3.

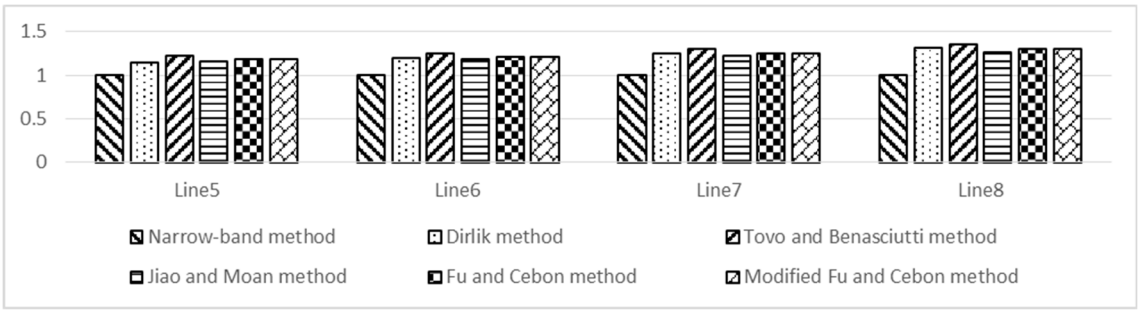
Fatigue life prediction of each mooring chain in Case A mooring system is performed, in which the narrow-band method, general wide-band methods including Dirlik method and Tovo and

Benasciutti method, dual narrow-band methods including Jiao and Moan method, Fu and Cebon method, and modified Fu and Cebon method, are used to predict the combined load process $X(t)$ of the LF load process $X_L(t)$ and WF load process $X_W(t)$.

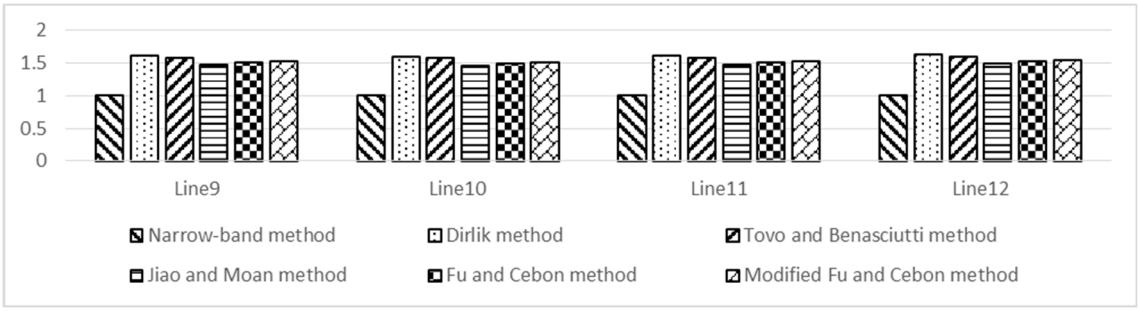
The ratios of fatigue lives of mooring chains predicted by the FM analysis based on general wide-band methods and dual narrow-band methods to those based on the narrow-band method at crown sections, bend sections and weld sections of mooring chains connecting to the fairleads of the semi-submersible, are shown in Figures 6.1 to 6.3.



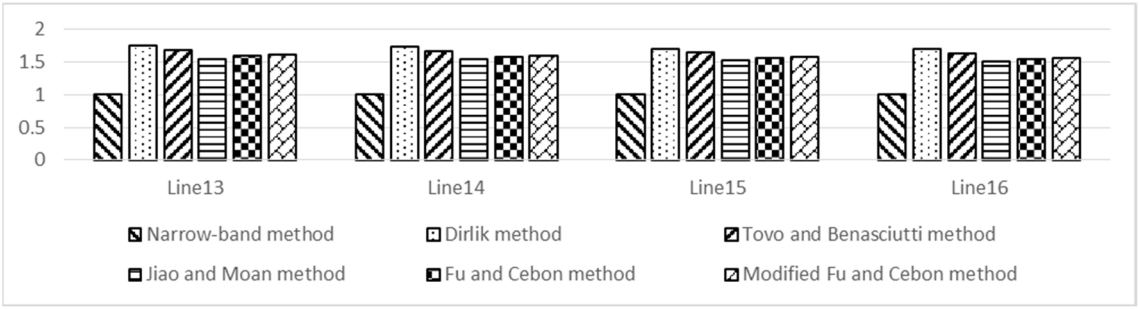
(a)



(b)

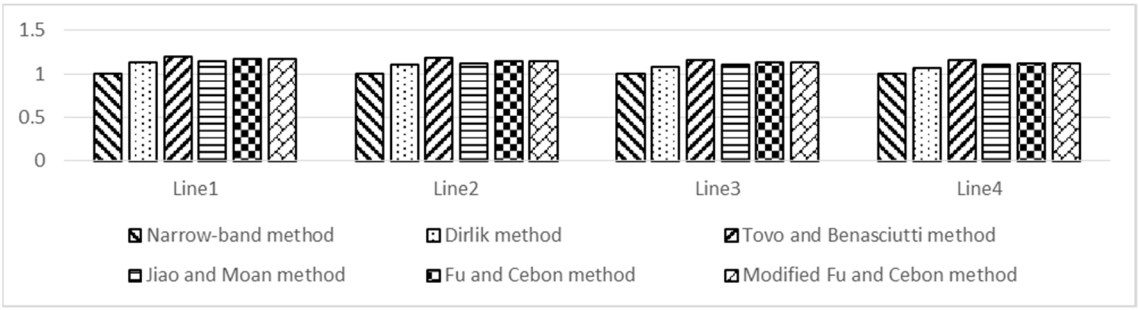


(c)

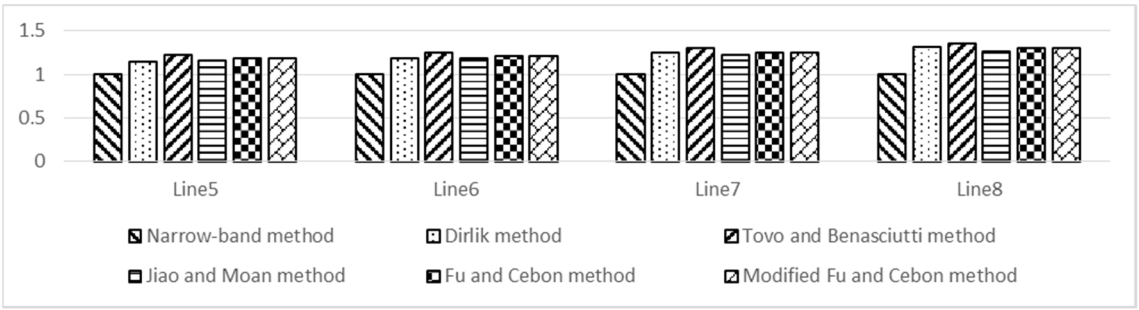


(d)

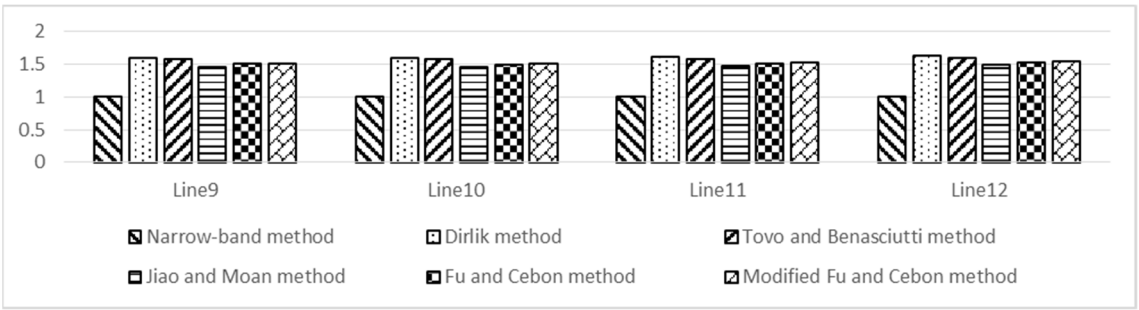
Figure 6.1: Ratios of fatigue lives predicted by the FM analysis based on wide-band methods to those based on the narrow-band method at crown sections of mooring chains: (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line12; (d) Line13 to Line 16.



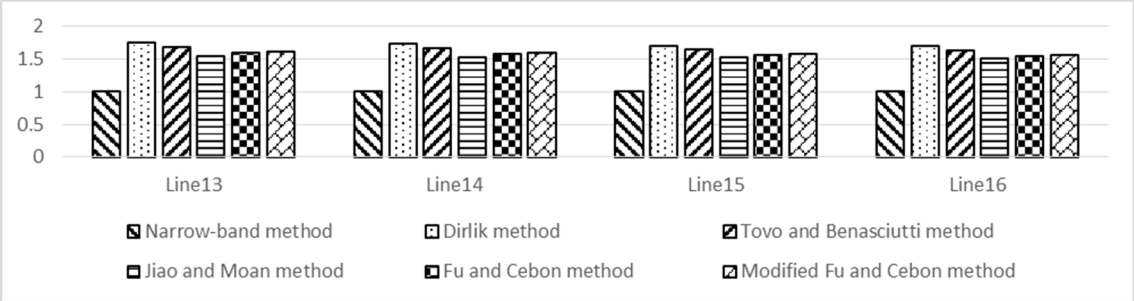
(a)



(b)

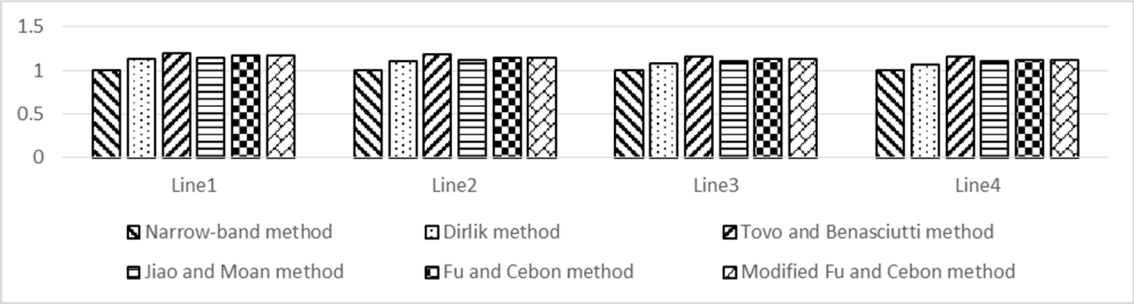


(c)

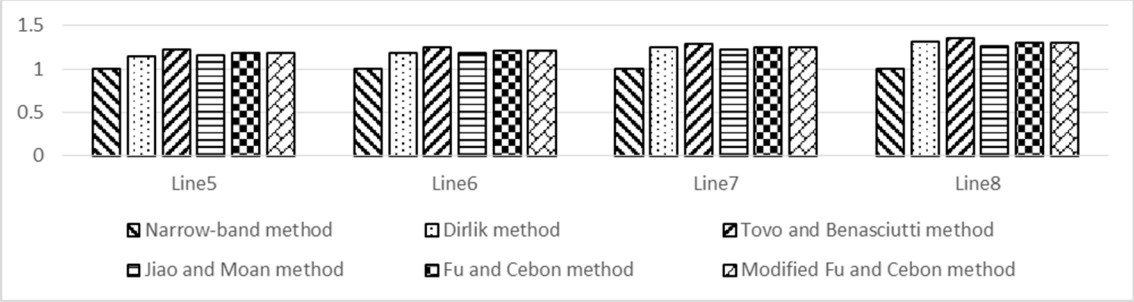


(d)

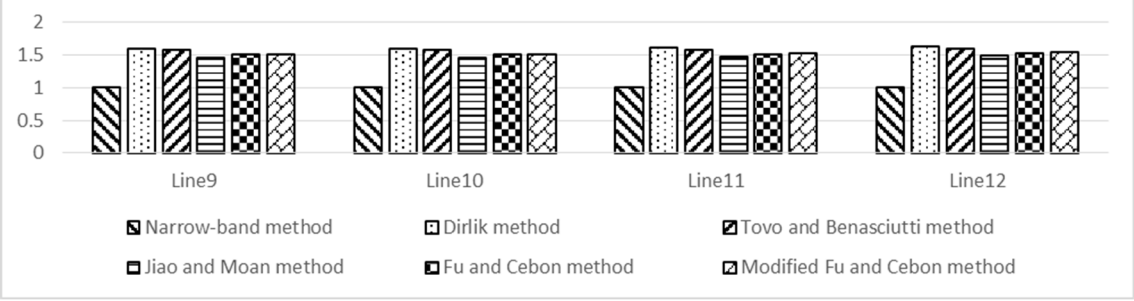
Figure 6.2: Ratios of fatigue lives predicted by the FM analysis based on wide-band methods to those based on the narrow-band method at bend sections of mooring chains. (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line 16.



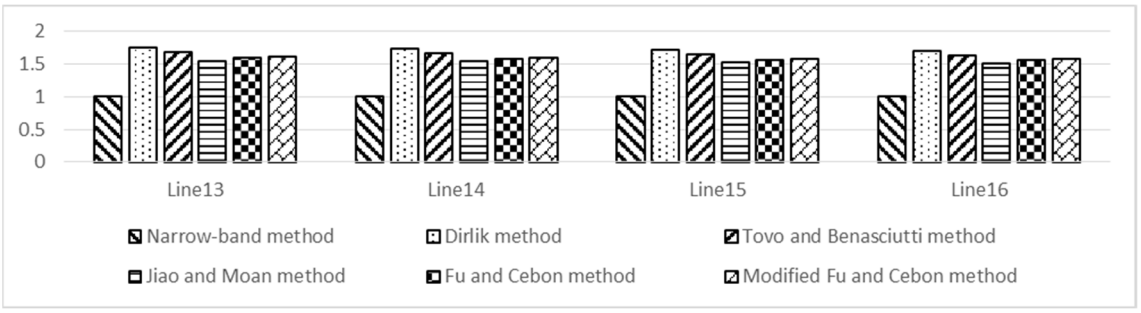
(a)



(b)



(c)



(d)

Figure 6.3: Ratios of fatigue lives predicted by the FM analysis based on wide-band methods to those based on the narrow-band method at weld sections of mooring chains. (a) Line 1 to Line 4; (b) Line 5 to Line 8; (c) Line 9 to Line 12; (d) Line 13 to Line16.

Figures 6.1-6.3 show that fatigue lives of mooring chains predicted by the FM analysis with use of the narrow-band method and wide-band methods are quite different. The predicted fatigue lives of mooring chains based on the narrow-band method are generally conservative than those of wide-band methods. The ratios ρ of fatigue lives of mooring chains estimated by wide-band methods to narrow-band method may vary from 1.067 to 1.752 in this case study.

Figures 6.1-6.3 also show the difference between fatigue lives of mooring chain predicted by the FM analysis based on the general wind-band methods (including Dirlik method and Tovo and Benasciutti method) and dual narrow-band methods (including Jiao and Moan method, Fu and Cebon method and modified Fu and Cebon method) is not significant.

The relative differences between the predicted fatigue lives of mooring chains based on Dirlik method and Tovo and Benasciutti method, and various dual narrow-band methods are listed in Tables 6.1 and 6.2, where the relative difference is calculated by:

$$\Delta = \frac{L_{GW} - L_{Dual}}{L_{GW}} \times 100\% \tag{6.31}$$

where L_{GW} is the fatigue life of a mooring chain calculated based on Dirlik method or Tovo and Benasciutti method, L_{Dual} is the fatigue life of a mooring chain calculated based on each dual narrow-band method.

Table 6.1 shows that the relative differences between the predicted fatigue lives of mooring chains based on Dirlik method and various dual narrow-band methods may vary from -11.3% to 5.2%. As shown in Table 6.2, the relative differences between the predicted fatigue lives of mooring chains based on Tovo and Benasciutti method and dual narrow-band methods may

vary from -2.4% to -7.8%, which indicates that in this case study fatigue lives of mooring chains predicted by the FM analysis based on Tovo and Benasciutti method are relatively less conservative than those based on dual narrow-band methods.

The relative differences between the predicted fatigue lives of mooring chains based on the narrow-band method and wide-band methods for some special cases (only 6 cases are given due to the limited space) are listed in Table 6.3 where the relative difference is calculated by:

$$\Delta = \frac{L_W - L_N}{L_N} \times 100\% \tag{6.32}$$

where L_W is the fatigue life of a mooring chain calculated based on each wide-band method. L_N is the fatigue life of a mooring chain calculated based on the narrow-band method.

Table 6.1: Relative differences between fatigue lives predicted by the FM analysis based on Dirlik method and dual narrow-band methods

	Jiao and Moan method			Fu and Cebon method			Modified Fu and Cebon method		
	Crown	Bend	Weld	Crown	Bend	Weld	Crown	Bend	Weld
Line1	1.4%	1.4%	1.2%	3.4%	3.4%	3.4%	3.6%	3.7%	3.6%
Line2	2.0%	2.1%	2.0%	4.1%	4.1%	4.0%	4.3%	4.4%	4.3%
Line3	2.6%	2.7%	2.4%	4.8%	4.7%	4.4%	5.0%	4.9%	4.7%
Line4	3.0%	2.9%	3.1%	4.9%	5.0%	5.0%	5.2%	5.1%	5.0%
Line5	0.5%	0.5%	0.3%	2.5%	2.6%	2.6%	3.0%	2.9%	2.9%
Line6	-0.8%	-0.6%	-0.5%	1.5%	1.7%	1.6%	1.9%	2.0%	1.9%
Line7	-2.2%	-2.0%	-2.2%	0.2%	0.3%	0.2%	0.6%	0.8%	0.7%
Line8	-3.7%	-3.7%	-3.7%	-1.3%	-1.3%	-1.4%	-0.8%	-0.8%	-0.8%
Line9	-8.6%	-8.7%	-8.7%	-6.4%	-6.4%	-6.4%	-5.4%	-5.5%	-5.4%
Line10	-8.7%	-8.7%	-8.7%	-6.4%	-6.4%	-6.4%	-5.5%	-5.5%	-5.4%
Line11	-8.8%	-8.8%	-8.8%	-6.5%	-6.5%	-6.5%	-5.5%	-5.6%	-5.6%
Line12	-9.0%	-9.1%	-9.0%	-6.6%	-6.6%	-6.6%	-5.8%	-5.8%	-5.8%
Line13	-11.3%	-11.3%	-11.3%	-8.6%	-8.7%	-8.7%	-7.7%	-7.7%	-7.7%
Line14	-11.1%	-11.1%	-11.2%	-8.6%	-8.6%	-8.6%	-7.6%	-7.6%	-7.6%
Line15	-11.0%	-11.0%	-11.1%	-8.6%	-8.5%	-8.5%	-7.5%	-7.5%	-7.5%
Line16	-10.9%	-10.9%	-10.9%	-8.4%	-8.4%	-8.4%	-7.4%	-7.4%	-7.3%

Table 6.2: Relative differences between fatigue lives predicted by the FM analysis based on Tovo and Benasciutti method and dual narrow-band methods

	Jiao and Moan method			Fu and Cebon method			Modified Fu and Cebon method		
	Crown	Bend	Weld	Crown	Bend	Weld	Crown	Bend	Weld
Line1	-4.8%	-4.8%	-5.0%	-2.9%	-2.9%	-2.9%	-2.7%	-2.6%	-2.7%
Line2	-4.8%	-4.8%	-4.9%	-2.9%	-2.9%	-3.0%	-2.7%	-2.6%	-2.7%
Line3	-4.7%	-4.6%	-4.7%	-2.7%	-2.7%	-2.8%	-2.4%	-2.5%	-2.5%
Line4	-4.6%	-4.5%	-4.3%	-2.8%	-2.6%	-2.5%	-2.5%	-2.5%	-2.5%
Line5	-5.2%	-5.2%	-5.2%	-3.2%	-3.2%	-3.0%	-2.8%	-2.9%	-2.7%
Line6	-5.6%	-5.5%	-5.4%	-3.4%	-3.3%	-3.3%	-3.1%	-3.0%	-3.1%
Line7	-5.9%	-5.8%	-5.8%	-3.7%	-3.6%	-3.5%	-3.2%	-3.2%	-3.1%
Line8	-6.2%	-6.2%	-6.3%	-3.9%	-3.9%	-4.0%	-3.4%	-3.4%	-3.5%
Line9	-6.9%	-6.9%	-6.9%	-4.6%	-4.6%	-4.6%	-3.6%	-3.6%	-3.6%
Line10	-6.9%	-6.9%	-6.9%	-4.6%	-4.6%	-4.6%	-3.6%	-3.6%	-3.6%
Line11	-6.9%	-6.9%	-6.9%	-4.5%	-4.5%	-4.5%	-3.6%	-3.6%	-3.6%
Line12	-6.9%	-6.9%	-6.9%	-4.5%	-4.4%	-4.4%	-3.7%	-3.6%	-3.6%
Line13	-7.7%	-7.7%	-7.7%	-4.9%	-4.9%	-5.0%	-4.0%	-4.0%	-4.0%
Line14	-7.7%	-7.7%	-7.8%	-5.0%	-5.1%	-5.1%	-4.0%	-4.0%	-4.0%
Line15	-7.7%	-7.7%	-7.7%	-5.2%	-5.1%	-5.1%	-4.0%	-4.0%	-4.0%
Line16	-7.7%	-7.7%	-7.7%	-5.1%	-5.1%	-5.0%	-4.0%	-4.0%	-4.0%

Table 6.3 shows that the relative differences between the predicted fatigue lives of mooring chains based on the four wide-band methods (Dirlik method, Jiao and Moan method, Fu and Cebon method and modified Fu and Cebon method) and the narrow-band method for these 6 cases are not always positive values. This indicates that fatigue lives predicted by the Dirlik method, Jiao and Moan method, Fu and Cebon method and modified Fu and Cebon method may not always be less conservative than those predicted by the narrow-band method in some cases, such as these 6 cases shown in Table 6.3.

However, Table 6.3 also shows that all of the relative differences between the predicted fatigue lives of mooring chains based on the Tovo and Benasciutti method and the narrow-band method for these 6 cases are positive values and this indicates that even in these 6 cases, the fatigue life of mooring chains predicted based on Tovo and Benasciutti method are still less conservative than those based on the narrow-band method.

Table 6.3: Relative differences between fatigue lives predicted by the FM analysis based on the narrow-band method and wide-band methods for some special cases

	σ_W(kN)	σ_L(kN)	$\nu_{0,W}$ (Hertz)	$\nu_{0,L}$ (Hertz)	Dirlik method	Tovo and Benasciutti method	Jiao and Moan method	Fu and Cebon method	Modified Fu and Cebon method
1	0.220	6.195	0.158	0.019	-8.12%	2.29%	-5.21%	-2.68%	-2.60%
2	0.246	13.291	0.203	0.012	-2.90%	3.60%	-0.40%	1.30%	1.30%
3	0.217	5.680	0.157	0.018	-7.84%	2.79%	-5.10%	-2.31%	-2.22%
4	8.554	824.220	0.161	0.010	-11.63%	0.85%	-1.59%	0.95%	0.85%
5	0.406	28.955	0.170	0.011	-10.01%	1.48%	-1.70%	-0.44%	-0.44%
6	0.580	5.738	0.156	0.021	7.65%	3.66%	-1.56%	2.84%	3.59%

6.4 Summary

An investigation on the effects of load combination methods on the fatigue life of mooring chain links predicted by the FM based mooring fatigue assessment approach was conducted. The narrow-band method, general wide-band methods (including Dirlik method and Tovo and Benasciutti method) for general wide-band load processes, dual narrow-band methods (including Jiao and Moan method, Fu and Cebon method and modified Fu and Cebon method) for dual narrow-band load processes, are considered in the investigation. The results show that:

- Fatigue life predicted by the FM based mooring fatigue assessment approach based on the narrow-band method generally provides conservative results compared with general wide-band methods and dual narrow-band methods.
- The difference between fatigue lives of mooring chains predicted by general wide-band methods and dual narrow-band methods is generally not significant.
- However, in some cases, fatigue lives of mooring chain links predicted by the FM based mooring fatigue assessment approach based on Dirlik method, Jiao and Moan method, Fu and Cebon method and modified Fu and Cebon method are even conservative than those predicted based on the narrow-band method.

Chapter 7. Conclusions and Recommendations

7.1 Conclusions

A fracture mechanics (FM) based offshore mooring assessment approach is developed for general mooring chain links in this thesis. Then the developed FM based mooring fatigue assessment approach is applied for addressing a series of unsolved offshore mooring problems including mooring chain links subjected to out-of-plane bending (OPB), mooring chain links subjected to torque, and mooring chain links tensioned over a curved surface. Finally, an investigation on the effects of load combination methods on fatigue lives of mooring chain links predicted by the FM based mooring fatigue assessment approach is conducted.

In the developed FM based offshore mooring assessment approach, initial cracks were assumed to propagate from surfaces of chain links and the stress intensity factors were calculated in terms of stress ranges determined by a finite element analysis. A hydrodynamic analysis of a semi-submersible operating at the centre of the Gulf of Mexico was carried out as a case study, in which a frequency-domain analysis was performed to estimate the low-frequency and wave-frequency motions, and the tension ranges of mooring lines were calculated based on the combined load process of low-frequency and wave-frequency.

A comparative study between T-N curves, S-N curves, and the developed FM based mooring fatigue assessment approach was made and a parametric study to investigate the impact of initial crack shape, critical crack depth, and initial crack sizes on fatigue life of a mooring chain was also conducted based on mooring line tensions achieved from case studies. The results show that:

- The fatigue lives predicted by the three approaches are in general well comparable if the safety factors suggested by API and DNVGL are considered in the T-N/S-N curves based approaches;
- The fatigue life of a mooring chain link predicted by the FM based mooring fatigue assessment approach is generally sensitive to initial crack shape and initial crack sizes;
- The fatigue life of a mooring chain link predicted by the FM based mooring fatigue assessment approach is relatively less sensitive to the critical crack depth.

The developed FM based mooring fatigue assessment approach is then applied for mechanism investigation on mooring chain links subjected to out-of-plane bending (OPB), mooring chain links subjected to torque, and mooring chain links tensioned over a curved surface. The results show that:

- Fatigue lives of mooring chain links are in general decreased significantly due to effects of OPB and curved surface;
- In contrast, the effect of torque induced by the chain twist on fatigue lives of mooring chain links is not evident.

Finally, an investigation on the effects of load combination methods on fatigue lives of mooring chain links predicted by the FM based mooring fatigue assessment approach is conducted. Narrow-band method, general wide-band methods (including Dirlik method and Tovo and Benasciutti method) for general wide-band load processes, dual narrow-band methods load combination methods (including Jiao and Moan method, Fu and Cebon method and modified Fu and Cebon method) for dual narrow-band load processes were considered in the investigation. The results show that:

- The FM based mooring fatigue assessment approach based on the narrow-band method generally provides conservative results compared with general wide-band methods and dual narrow-band methods;
- The difference between fatigue lives of mooring chains predicted by the FM based mooring fatigue assessment approach based on general wide-band methods and dual narrow-band methods is generally not significant.

7.2 Recommendations and future work

Taking into account the limited scope and time frame of this research study, the following research topics are recommended for future work:

- As an extension of fatigue assessment for offshore mooring chain links, reliability based fatigue assessment for offshore mooring systems is recommended as a future research topic to taken into account several uncertainties in FM based mooring fatigue assessment, i.e. initial crack depth, critical crack depth, Model uncertainty in geometry function, Corrosion rate.
- Risk-Based Inspection (RBI) could identify, assess and predict structure risk induced by crack growth, and it can address the risk controlled through periodic inspection. Fatigue reliability based risk-based inspection planning and risk analysis for offshore mooring systems is recommended for future work;

- Fatigue tests for offshore mooring chain links subjected to OPB and offshore mooring chain links tensioned over curved surfaces to generate S-N/T-N curves for mooring chain links subjected to OPB and tensioned over curved surfaces.

Appendixes

Nomenclature

WF Tz	Zero up-crossing frequency of wave-frequency mooring line tension in Hertz
WF StDev	Standard deviation of wave-frequency mooring line tension in kN
LF Tz	Zero up-crossing frequency of low-frequency mooring line tension in Hertz
LF StDev	Standard deviation of low-frequency mooring line tension in kN

Appendix A: Data of mooring line tensions of designed mooring system A

	Line1				Line2			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	4.92	0.25	85.08	13.29	4.88	0.27	85.44	14.77
2	8.15	2.69	84.98	13.22	8.13	2.88	85.34	14.70
3	8.93	3.78	85.00	13.20	8.83	3.98	85.36	14.67
4	10.04	4.19	85.05	13.20	9.87	4.31	85.42	14.67
5	11.56	8.61	85.59	13.38	11.44	8.81	85.94	14.87
6	4.71	0.68	90.05	15.23	4.68	0.74	90.37	16.95
7	8.07	6.60	89.94	15.13	8.05	7.12	90.27	16.84
8	8.74	8.95	88.79	14.60	8.66	9.49	89.12	16.23
9	9.94	10.01	88.23	14.37	9.78	10.35	88.57	15.98
10	8.72	13.64	101.48	21.86	8.64	14.48	101.73	24.35
11	10.10	15.91	100.02	20.63	9.93	16.46	100.28	22.97
12	7.40	4.16	107.88	30.44	7.37	4.56	108.05	33.94
13	7.75	11.90	114.19	85.95	7.72	12.92	114.30	96.72
14	8.78	26.21	112.43	88.31	8.71	27.83	112.60	99.57
15	7.66	15.46	114.05	241.17	7.63	16.81	114.12	274.45
16	6.35	0.22	53.50	6.20	6.39	0.21	48.02	5.59
17	7.71	0.96	53.45	6.18	7.58	0.87	48.01	5.58
18	10.38	2.17	53.47	6.18	10.59	2.14	48.01	5.58
19	11.72	3.51	53.48	6.18	11.79	3.49	48.01	5.58
20	6.35	0.61	54.24	6.30	6.40	0.59	48.15	5.61
21	7.65	2.64	54.24	6.30	7.54	2.43	48.15	5.61
22	10.02	5.70	54.32	6.30	10.12	5.50	48.17	5.61
23	9.93	9.15	59.40	7.18	9.98	8.80	49.22	5.85
24	6.73	2.39	61.48	7.58	6.74	2.30	49.61	5.96
25	9.91	12.53	69.81	9.46	9.94	12.05	51.95	6.57
26	7.05	6.10	74.15	15.02	7.03	5.83	52.97	9.76
27	9.83	17.39	73.17	21.50	9.87	16.65	52.80	14.31
28	6.92	9.97	73.11	32.81	6.92	9.53	52.22	21.54
29	6.71	7.65	63.87	48.23	6.75	7.07	49.00	36.28
30	5.50	0.44	97.48	17.52	5.56	0.42	95.69	16.57
31	8.05	3.57	97.41	17.44	8.08	3.45	95.60	16.49
32	8.66	4.78	97.51	17.42	8.71	4.67	95.69	16.47
33	9.73	5.22	97.62	17.42	9.79	5.16	95.80	16.47
34	11.45	12.01	97.93	17.58	11.45	11.79	96.12	16.63
35	5.43	1.28	100.58	19.30	5.48	1.22	98.93	18.25
36	7.90	9.09	100.50	19.22	7.94	8.74	98.84	18.19
37	8.71	12.42	99.92	18.73	8.77	12.16	98.21	17.72
38	9.89	14.11	99.69	18.56	9.94	13.93	97.96	17.55
39	8.74	19.43	108.17	26.23	8.81	19.04	106.98	24.78
40	10.03	22.75	107.33	25.16	10.09	22.44	106.07	23.78
41	11.78	26.41	104.09	21.93	11.77	25.92	102.62	20.73
42	7.07	6.72	112.09	34.77	7.08	6.34	111.27	32.85
43	8.76	26.18	114.51	42.02	8.83	25.68	113.89	39.76
44	10.15	31.42	113.91	39.59	10.20	31.04	113.20	37.39

45	7.42	18.52	115.70	85.03	7.45	17.55	115.35	80.80
46	8.82	38.74	115.06	87.10	8.89	38.09	114.37	82.04
47	7.23	27.91	115.51	189.08	7.26	26.27	115.15	180.60
48	5.90	0.47	98.88	23.47	5.90	0.47	98.06	23.76
49	8.44	3.54	98.85	23.35	8.46	3.64	98.03	23.64
50	9.09	5.23	98.98	23.35	9.09	5.39	98.15	23.64
51	9.95	5.80	99.10	23.36	9.91	5.94	98.27	23.65
52	11.59	13.10	99.18	23.41	11.50	13.28	98.35	23.70
53	5.87	1.36	100.57	24.64	5.87	1.37	99.79	24.95
54	8.33	8.01	100.69	24.64	8.36	8.25	99.91	24.95
55	9.28	12.99	100.91	24.74	9.28	13.42	100.13	25.05
56	10.27	15.41	100.25	24.16	10.23	15.79	99.44	24.45
57	9.34	20.12	108.06	33.14	9.34	20.76	107.49	33.54
58	10.43	24.71	105.42	29.45	10.38	25.33	104.76	29.79
59	11.94	28.64	102.04	25.79	11.85	28.98	101.28	26.10
60	6.73	5.16	109.57	36.81	6.76	5.21	109.08	37.24
61	9.38	27.05	113.89	51.44	9.38	27.97	113.57	52.03
62	10.54	34.17	111.56	42.25	10.49	35.05	111.15	42.73
63	7.40	14.05	114.30	85.04	7.45	14.38	114.09	86.09
64	9.30	41.58	115.29	117.86	9.31	43.16	115.04	119.20
65	5.63	0.38	89.53	11.06	5.57	0.40	89.90	12.18
66	8.03	2.82	89.46	11.00	8.02	3.06	89.82	12.12
67	8.80	3.89	89.49	10.99	8.73	4.16	89.86	12.10
68	10.12	4.59	89.56	10.99	9.98	4.77	89.94	12.10
69	11.79	10.90	90.14	11.15	11.69	11.25	90.51	12.28
70	5.56	1.08	94.92	12.83	5.50	1.15	95.27	14.13
71	7.89	7.24	94.83	12.76	7.89	7.85	95.18	14.06
72	8.85	10.29	93.65	12.29	8.78	10.95	94.01	13.53
73	10.22	12.42	93.11	12.07	10.10	12.93	93.47	13.30
74	8.89	16.22	105.69	18.88	8.82	17.24	105.95	20.80
75	10.34	20.11	104.44	17.85	10.23	20.93	104.71	19.66
76	12.08	24.09	99.97	15.07	11.98	24.82	100.28	16.59
77	7.03	5.41	110.74	26.25	7.04	5.87	110.91	28.90
78	8.91	21.95	113.36	31.96	8.84	23.30	113.51	35.19
79	10.46	27.90	112.57	29.65	10.34	29.00	112.73	32.65
80	12.04	33.61	109.51	23.85	11.95	34.65	109.70	26.28
81	7.40	14.85	115.18	68.31	7.41	16.12	115.24	74.71
82	7.22	22.30	114.97	152.85	7.22	24.22	115.08	167.65
83	6.36	0.22	55.04	5.68	6.39	0.21	48.29	4.90
84	7.79	0.99	54.97	5.67	7.66	0.91	48.27	4.89
85	10.48	2.22	54.97	5.67	10.57	2.13	48.27	4.89
86	11.71	3.40	55.00	5.67	11.79	3.39	48.27	4.89
87	12.74	7.85	55.06	5.68	12.77	8.00	48.29	4.89
88	6.36	0.60	56.04	5.84	6.40	0.59	48.50	4.94
89	7.59	2.58	56.03	5.84	7.52	2.44	48.49	4.94
90	10.01	5.21	56.12	5.84	10.07	5.17	48.52	4.94
91	11.54	8.08	55.71	5.77	11.59	8.21	48.44	4.92

92	9.83	8.06	62.59	6.89	9.89	8.10	50.11	5.25
93	11.56	12.95	59.86	6.43	11.59	13.19	49.48	5.12
94	13.01	17.41	57.06	5.98	13.01	17.71	48.78	4.99
95	6.73	2.37	65.05	7.40	6.73	2.33	50.70	5.41
96	9.76	10.92	74.58	9.55	9.82	11.04	54.00	6.15
97	11.63	18.10	69.20	8.22	11.65	18.43	52.33	5.73
98	12.97	24.45	62.67	6.92	12.97	24.82	50.34	5.28
99	7.01	5.88	79.28	15.91	7.00	5.82	55.87	9.54
100	6.90	9.28	79.40	37.97	6.90	9.36	56.51	22.35
101	6.72	6.60	70.63	60.89	6.74	6.78	53.01	39.02
102	6.64	5.68	61.68	82.50	6.66	5.98	49.67	57.47
103	4.88	0.31	96.51	19.93	4.94	0.30	94.76	18.69
104	8.10	3.27	96.43	19.83	8.14	3.18	94.67	18.59
105	8.70	4.36	96.52	19.80	8.74	4.28	94.75	18.58
106	9.59	4.52	96.63	19.82	9.64	4.47	94.85	18.58
107	11.17	9.14	96.93	20.04	11.15	8.94	95.17	18.80
108	4.68	0.87	99.61	22.32	4.73	0.82	98.01	20.90
109	8.02	8.08	99.54	22.17	8.06	7.80	97.92	20.78
110	8.53	10.47	98.94	21.56	8.59	10.25	97.28	20.20
111	9.52	10.98	98.71	21.29	9.56	10.81	97.03	19.96
112	8.52	16.02	107.44	30.75	8.58	15.67	106.27	28.83
113	9.67	17.48	106.59	29.38	9.71	17.18	105.35	27.47
114	11.69	20.42	103.25	25.39	11.66	19.91	101.82	23.75
115	7.34	5.28	111.56	41.40	7.38	4.97	110.74	38.74
116	8.53	21.27	114.13	50.59	8.59	20.81	113.47	47.13
117	7.69	14.72	115.75	119.24	7.73	14.03	115.38	110.35
118	8.62	30.74	115.07	126.06	8.67	30.23	114.49	116.58
119	7.58	19.07	115.26	345.54	7.64	18.12	114.92	316.60
120	6.95	11.44	110.20	573.67	6.98	10.75	109.72	522.60
121	8.81	49.14	107.51	433.88	8.85	48.31	106.60	395.85
122	6.21	8.55	105.09	824.22	6.22	7.91	104.51	749.82
123	5.90	0.41	91.92	28.96	5.90	0.41	91.20	29.40
124	8.26	2.88	91.84	28.81	8.27	2.96	91.12	29.25
125	8.94	4.02	91.92	28.78	8.93	4.14	91.20	29.23
126	9.66	4.19	92.01	28.78	9.61	4.28	91.28	29.22
127	11.39	9.00	92.13	28.90	11.25	9.10	91.40	29.34
128	5.87	1.18	94.00	30.89	5.87	1.18	93.31	31.37
129	8.12	6.68	94.09	30.85	8.15	6.88	93.39	31.32
130	8.89	9.91	94.26	30.88	8.90	10.31	93.56	31.33
131	9.70	10.73	93.40	30.01	9.65	11.08	92.69	30.47
132	8.92	15.52	103.29	42.15	8.94	16.18	102.72	42.73
133	9.87	17.52	99.86	37.04	9.82	18.09	99.23	37.57
134	6.75	4.61	105.62	47.85	6.78	4.67	105.12	48.51
135	8.96	20.86	111.56	67.73	8.97	21.76	111.21	68.64
136	7.30	11.25	112.65	127.12	7.34	11.49	112.38	128.90
137	9.04	31.39	113.20	189.54	9.06	32.84	112.91	192.20
138	7.00	14.89	110.86	359.31	7.03	15.16	110.63	364.77

	Line3				Line4			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	4.86	0.29	85.73	16.13	4.82	0.31	86.81	17.26
2	8.11	3.07	85.63	16.06	8.09	3.20	86.72	17.17
3	8.76	4.17	85.66	16.03	8.71	4.29	86.75	17.15
4	9.74	4.42	85.71	16.03	9.66	4.50	86.81	17.14
5	11.30	8.99	86.24	16.26	11.27	9.20	87.33	17.38
6	4.66	0.80	90.65	18.54	4.63	0.86	91.68	19.85
7	8.03	7.60	90.55	18.41	8.00	7.95	91.58	19.71
8	8.59	9.98	89.40	17.76	8.54	10.32	90.46	19.01
9	9.65	10.68	88.86	17.48	9.58	10.93	89.93	18.70
10	8.57	15.26	101.94	26.67	8.52	15.79	102.73	28.63
11	9.80	17.00	100.50	25.14	9.73	17.42	101.34	26.99
12	7.35	4.93	108.20	37.12	7.32	5.25	108.75	39.74
13	7.70	13.87	114.39	106.95	7.67	14.65	114.65	115.93
14	8.66	29.34	112.75	110.25	8.62	30.27	113.18	119.59
15	7.60	18.05	114.17	306.46	7.56	19.11	114.40	335.11
16	6.39	0.21	47.85	5.67	6.35	0.21	52.96	6.38
17	7.43	0.78	47.84	5.67	7.39	0.77	52.92	6.37
18	10.77	2.13	47.84	5.67	10.83	2.16	52.93	6.37
19	11.83	3.47	47.84	5.67	11.83	3.47	52.94	6.37
20	6.40	0.58	47.92	5.69	6.35	0.60	53.56	6.49
21	7.41	2.26	47.91	5.69	7.34	2.22	53.56	6.49
22	10.20	5.33	47.91	5.69	10.23	5.24	53.58	6.49
23	10.02	8.47	48.37	5.85	10.02	8.25	57.45	7.22
24	6.71	2.27	48.68	5.97	6.68	2.30	59.45	7.66
25	9.95	11.60	49.67	6.39	9.94	11.27	65.94	9.25
26	6.98	5.66	51.01	9.63	6.93	5.62	71.22	15.32
27	9.89	15.91	50.70	14.11	9.89	15.38	70.01	22.00
28	6.89	9.19	51.79	22.36	6.86	9.06	72.48	36.71
29	6.74	6.71	50.41	39.93	6.70	6.57	66.77	60.33
30	5.61	0.40	94.18	15.44	5.67	0.38	93.43	14.07
31	8.10	3.29	94.09	15.36	8.11	3.05	93.33	14.00
32	8.76	4.50	94.17	15.34	8.82	4.23	93.41	13.98
33	9.88	5.05	94.27	15.35	10.01	4.86	93.51	13.98
34	11.48	11.53	94.61	15.49	11.59	11.19	93.85	14.11
35	5.54	1.15	97.54	17.01	5.60	1.08	96.83	15.50
36	7.97	8.28	97.44	16.93	7.99	7.69	96.74	15.43
37	8.84	11.75	96.77	16.51	8.90	11.09	96.05	15.05
38	10.02	13.62	96.50	16.35	10.13	13.11	95.77	14.90
39	8.88	18.42	105.95	23.07	8.94	17.43	105.41	21.03
40	10.16	21.97	104.98	22.13	10.26	21.17	104.42	20.16
41	11.79	25.35	101.37	19.30	11.88	24.63	100.73	17.59
42	7.09	5.93	110.55	30.59	7.08	5.48	110.17	27.89
43	8.91	24.84	113.32	37.01	8.98	23.52	113.01	33.74
44	10.28	30.41	112.58	34.80	10.38	29.34	112.25	31.70
45	7.48	16.47	115.05	75.64	7.48	15.21	114.93	69.51

46	8.95	36.89	113.87	76.74	9.01	34.88	113.68	70.52
47	7.29	24.53	114.82	169.97	7.29	22.62	114.62	155.59
48	5.90	0.47	97.49	23.85	5.90	0.47	97.82	23.62
49	8.47	3.70	97.46	23.74	8.46	3.63	97.79	23.51
50	9.09	5.48	97.57	23.73	9.09	5.38	97.90	23.49
51	9.89	6.02	97.69	23.74	9.91	5.93	98.02	23.52
52	11.44	13.37	97.78	23.79	11.50	13.25	98.12	23.55
53	5.87	1.36	99.26	25.04	5.87	1.35	99.58	24.80
54	8.37	8.37	99.38	25.03	8.36	8.22	99.70	24.80
55	9.28	13.65	99.59	25.15	9.28	13.40	99.91	24.90
56	10.20	16.02	98.89	24.55	10.22	15.78	99.22	24.32
57	9.35	21.15	107.09	33.65	9.35	20.73	107.32	33.33
58	10.36	25.68	104.31	29.90	10.38	25.30	104.57	29.61
59	11.80	29.19	100.76	26.18	11.85	28.93	101.07	25.93
60	6.78	5.24	108.75	37.37	6.76	5.19	108.94	37.03
61	9.38	28.49	113.34	52.19	9.38	27.94	113.46	51.71
62	10.46	35.55	110.85	42.85	10.49	35.00	111.01	42.45
63	7.47	14.52	113.92	86.36	7.45	14.33	113.99	85.50
64	9.31	44.06	114.86	119.61	9.31	43.12	114.96	118.56
65	5.53	0.42	90.21	13.20	5.48	0.44	91.35	14.03
66	8.02	3.28	90.14	13.14	8.00	3.44	91.28	13.95
67	8.68	4.41	90.18	13.12	8.64	4.57	91.32	13.94
68	9.86	4.95	90.25	13.12	9.78	5.06	91.40	13.93
69	11.59	11.59	90.83	13.31	11.56	11.86	91.97	14.14
70	5.45	1.22	95.56	15.31	5.41	1.28	96.60	16.27
71	7.88	8.41	95.48	15.24	7.86	8.83	96.52	16.20
72	8.73	11.57	94.31	14.66	8.68	11.97	95.39	15.57
73	9.99	13.42	93.78	14.42	9.93	13.74	94.87	15.32
74	8.76	18.20	106.16	22.55	8.70	18.79	106.88	23.99
75	10.13	21.69	104.93	21.32	10.07	22.18	105.70	22.67
76	11.90	25.55	100.54	17.99	11.88	26.16	101.45	19.14
77	7.05	6.29	111.06	31.31	7.04	6.68	111.54	33.30
78	8.79	24.53	113.63	38.12	8.72	25.35	114.01	40.55
79	10.25	30.02	112.86	35.39	10.19	30.68	113.28	37.65
80	11.87	35.62	109.87	28.49	11.84	36.39	110.41	30.32
81	7.41	17.27	115.28	80.40	7.39	18.28	115.47	85.01
82	7.22	25.96	115.17	181.00	7.20	27.59	115.40	191.70
83	6.38	0.22	48.04	4.89	6.34	0.23	54.37	5.55
84	7.45	0.82	48.03	4.88	7.30	0.78	54.33	5.55
85	10.66	2.05	48.04	4.88	10.67	2.02	54.35	5.53
86	11.87	3.39	48.04	4.88	11.89	3.41	54.36	5.53
87	12.80	8.21	48.04	4.88	12.83	8.47	54.39	5.54
88	6.39	0.60	48.11	4.92	6.34	0.63	55.05	5.65
89	7.40	2.32	48.10	4.92	7.33	2.30	55.05	5.65
90	10.13	5.16	48.11	4.90	10.14	5.25	55.10	5.65
91	11.63	8.39	48.07	4.89	11.64	8.63	54.78	5.59
92	9.95	8.19	48.62	5.07	9.97	8.41	59.50	6.38

93	11.63	13.53	48.35	5.00	11.63	13.95	57.35	6.02
94	13.02	18.17	48.14	4.92	13.03	18.77	55.50	5.72
95	6.70	2.33	48.94	5.20	6.66	2.40	61.63	6.79
96	9.88	11.21	49.95	5.61	9.90	11.55	68.47	8.32
97	11.67	18.89	49.13	5.31	11.68	19.48	63.60	7.23
98	12.97	25.43	48.50	5.07	12.97	26.19	58.88	6.30
99	6.96	5.81	50.87	8.47	6.93	5.95	72.73	13.50
100	6.87	9.57	50.61	19.04	6.83	9.94	72.08	29.80
101	6.72	7.17	48.68	33.21	6.67	7.74	64.42	44.64
102	6.65	6.56	46.82	48.35	6.61	7.36	56.62	54.73
103	5.02	0.28	93.30	17.24	5.08	0.26	92.60	15.54
104	8.17	3.05	93.21	17.16	8.19	2.85	92.50	15.47
105	8.79	4.15	93.28	17.14	8.86	3.96	92.57	15.44
106	9.73	4.40	93.38	17.14	9.88	4.29	92.66	15.45
107	11.19	8.76	93.71	17.33	11.33	8.59	93.00	15.62
108	4.79	0.77	96.66	19.27	4.84	0.71	96.01	17.34
109	8.09	7.44	96.57	19.13	8.12	6.94	95.92	17.24
110	8.65	9.92	95.89	18.61	8.72	9.40	95.22	16.76
111	9.65	10.58	95.62	18.39	9.79	10.25	94.94	16.58
112	8.64	15.15	105.28	26.51	8.71	14.34	104.72	24.03
113	9.80	16.81	104.30	25.27	9.94	16.27	103.79	22.74
114	11.70	19.47	100.61	21.88	11.83	19.07	100.02	19.70
115	7.42	4.64	110.05	35.74	7.44	4.25	109.72	32.21
116	8.66	20.12	112.92	43.40	8.73	19.03	112.66	39.16
117	7.78	13.22	115.05	100.41	7.81	12.23	114.88	89.34
118	8.72	29.34	113.98	105.97	8.78	27.78	113.70	94.15
119	7.69	17.02	114.63	285.03	7.73	15.73	114.51	250.69
120	7.02	10.03	109.32	466.96	7.05	9.24	109.14	406.34
121	8.90	46.97	105.84	354.07	8.97	44.66	105.50	308.12
122	6.24	7.29	103.92	664.38	6.27	6.71	103.61	570.96
123	5.90	0.41	90.72	29.55	5.90	0.40	91.12	29.21
124	8.28	3.01	90.64	29.40	8.27	2.96	91.05	29.06
125	8.92	4.20	90.71	29.37	8.93	4.13	91.12	29.03
126	9.58	4.34	90.80	29.36	9.61	4.28	91.21	29.03
127	11.16	9.16	90.91	29.47	11.23	9.09	91.32	29.15
128	5.87	1.18	92.83	31.52	5.87	1.17	93.22	31.15
129	8.17	7.01	92.91	31.45	8.15	6.88	93.30	31.11
130	8.91	10.56	93.08	31.48	8.91	10.33	93.47	31.12
131	9.63	11.31	92.20	30.61	9.65	11.10	92.60	30.26
132	8.95	16.58	102.33	42.89	8.94	16.21	102.62	42.40
133	9.79	18.44	98.80	37.72	9.82	18.11	99.13	37.30
134	6.80	4.70	104.77	48.69	6.78	4.65	104.68	48.94
135	8.99	22.31	110.97	68.85	8.98	21.80	111.13	68.05
136	7.36	11.63	112.20	129.26	7.34	11.48	112.32	127.76
137	9.07	33.73	112.71	192.72	9.06	32.92	112.85	190.33
138	7.06	15.32	110.48	365.85	7.04	15.13	110.62	361.08

	Line5				Line6			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	4.82	0.31	86.78	17.26	4.86	0.29	85.70	16.13
2	8.09	3.20	86.69	17.17	8.11	3.08	85.61	16.06
3	8.71	4.29	86.72	17.15	8.76	4.17	85.63	16.04
4	9.66	4.50	86.78	17.14	9.74	4.42	85.69	16.03
5	11.27	9.20	87.31	17.38	11.30	8.99	86.22	16.26
6	4.63	0.86	91.64	19.85	4.66	0.81	90.62	18.54
7	8.00	7.96	91.55	19.71	8.03	7.60	90.52	18.41
8	8.54	10.32	90.43	19.01	8.59	9.99	89.37	17.76
9	9.58	10.93	89.90	18.69	9.65	10.68	88.83	17.48
10	8.52	15.79	102.71	28.63	8.57	15.27	101.92	26.66
11	9.73	17.42	101.31	26.98	9.80	17.01	100.47	25.14
12	7.32	5.25	108.71	39.74	7.35	4.93	108.17	37.12
13	7.67	14.65	114.60	115.94	7.70	13.87	114.35	106.94
14	8.62	30.28	113.14	119.59	8.66	29.35	112.71	110.25
15	7.56	19.11	114.32	335.12	7.60	18.05	114.11	306.45
16	5.90	0.41	90.94	29.18	5.90	0.41	90.62	29.52
17	8.27	2.96	90.87	29.02	8.28	3.01	90.54	29.37
18	8.93	4.14	90.94	29.01	8.92	4.21	90.62	29.36
19	9.61	4.29	91.01	28.99	9.58	4.34	90.69	29.35
20	5.87	1.17	93.05	31.13	5.87	1.18	92.74	31.50
21	8.15	6.88	93.13	31.07	8.17	7.01	92.82	31.44
22	8.90	10.33	93.30	31.09	8.91	10.56	92.99	31.47
23	8.94	16.21	102.51	42.37	8.95	16.59	102.27	42.87
24	6.78	4.65	104.64	48.75	6.80	4.70	104.72	48.67
25	8.98	21.80	111.06	68.01	8.99	22.31	110.93	68.82
26	7.34	11.49	112.28	127.64	7.36	11.63	112.18	129.22
27	9.06	32.93	112.79	190.23	9.07	33.73	112.68	192.66
28	7.04	15.16	110.55	360.71	7.06	15.32	110.45	365.68
29	6.26	10.34	104.88	651.12	6.26	10.38	104.71	661.26
30	5.07	0.26	92.58	15.55	5.02	0.28	93.29	17.24
31	8.19	2.86	92.49	15.47	8.17	3.05	93.20	17.16
32	8.86	3.96	92.55	15.46	8.79	4.15	93.28	17.14
33	9.88	4.29	92.65	15.46	9.73	4.40	93.37	17.13
34	11.33	8.59	92.98	15.62	11.19	8.76	93.70	17.32
35	4.84	0.71	96.00	17.34	4.79	0.77	96.66	19.26
36	8.12	6.93	95.90	17.25	8.09	7.43	96.56	19.14
37	8.72	9.40	95.20	16.77	8.65	9.91	95.88	18.61
38	9.79	10.25	94.92	16.57	9.65	10.58	95.61	18.39
39	8.71	14.33	104.70	24.02	8.64	15.15	105.26	26.51
40	9.94	16.26	103.77	22.75	9.80	16.81	104.29	25.28
41	11.83	19.07	100.00	19.69	11.70	19.48	100.60	21.88
42	7.44	4.25	109.68	32.21	7.41	4.64	110.03	35.74
43	8.73	19.03	112.62	39.16	8.66	20.11	112.89	43.40
44	10.11	22.45	111.84	36.48	9.96	23.18	112.14	40.48
45	7.81	12.23	114.84	89.36	7.78	13.22	115.03	100.41

46	8.78	27.77	113.67	94.17	8.72	29.33	113.96	105.97
47	7.73	15.72	114.47	250.73	7.69	17.01	114.61	285.02
48	6.34	0.23	54.18	5.55	6.38	0.22	47.90	4.92
49	7.30	0.78	54.14	5.55	7.44	0.82	47.89	4.92
50	10.65	2.01	54.15	5.55	10.67	2.05	47.90	4.91
51	11.89	3.41	54.17	5.55	11.87	3.39	47.90	4.90
52	12.83	8.46	54.20	5.55	12.80	8.20	47.90	4.91
53	6.34	0.63	54.86	5.65	6.39	0.60	47.96	4.93
54	7.32	2.30	54.85	5.65	7.39	2.31	47.96	4.94
55	10.13	5.24	54.89	5.65	10.13	5.16	47.96	4.93
56	11.64	8.63	54.59	5.61	11.63	8.39	47.93	4.92
57	9.96	8.41	59.20	6.36	9.95	8.19	48.41	5.09
58	11.64	13.96	57.11	6.02	11.63	13.52	48.16	5.02
59	13.03	18.75	55.31	5.72	13.02	18.16	47.99	4.94
60	6.67	2.39	61.40	6.80	6.70	2.33	48.74	5.22
61	9.90	11.54	67.89	8.28	9.88	11.20	49.53	5.61
62	11.68	19.48	63.22	7.22	11.67	18.88	48.82	5.33
63	6.93	5.96	72.32	13.46	6.96	5.81	50.38	8.48
64	9.82	15.78	70.23	18.64	9.80	15.33	49.47	12.14
65	5.48	0.44	91.35	14.03	5.53	0.42	90.23	13.20
66	8.00	3.44	91.28	13.95	8.02	3.28	90.15	13.14
67	8.64	4.58	91.32	13.95	8.68	4.41	90.19	13.12
68	9.78	5.06	91.40	13.95	9.86	4.95	90.26	13.12
69	11.56	11.86	91.97	14.15	11.60	11.59	90.84	13.31
70	5.41	1.28	96.60	16.27	5.46	1.22	95.57	15.31
71	7.86	8.83	96.51	16.20	7.88	8.41	95.48	15.24
72	8.68	11.97	95.39	15.57	8.73	11.60	94.32	14.66
73	9.93	13.74	94.87	15.32	9.99	13.42	93.79	14.42
74	8.70	18.78	106.86	23.99	8.76	18.19	106.16	22.55
75	10.07	22.18	105.69	22.68	10.13	21.69	104.94	21.32
76	11.88	26.16	101.45	19.14	11.90	25.56	100.55	18.00
77	7.04	6.68	111.51	33.31	7.05	6.29	111.05	31.32
78	8.72	25.35	113.98	40.55	8.78	24.54	113.62	38.12
79	10.19	30.68	113.26	37.67	10.25	30.02	112.86	35.39
80	11.85	36.43	110.40	30.33	11.86	35.59	109.87	28.49
81	7.39	18.30	115.44	85.04	7.41	17.27	115.27	80.42
82	7.20	27.61	115.38	191.81	7.22	25.98	115.18	181.08
83	5.90	0.47	98.01	23.64	5.90	0.47	97.59	23.87
84	8.46	3.63	97.98	23.53	8.47	3.70	97.56	23.75
85	9.09	5.38	98.10	23.53	9.09	5.48	97.68	23.74
86	9.91	5.94	98.22	23.54	9.89	6.02	97.80	23.76
87	11.49	13.25	98.30	23.57	11.44	13.37	97.89	23.80
88	5.87	1.35	99.74	24.82	5.87	1.36	99.35	25.04
89	8.36	8.23	99.86	24.82	8.37	8.38	99.46	25.04
90	9.28	13.40	100.08	24.92	9.28	13.68	99.69	25.16
91	10.23	15.77	99.39	24.34	10.20	16.02	98.99	24.56
92	9.35	20.74	107.42	33.34	9.35	21.14	107.16	33.66

93	10.38	25.31	104.69	29.62	10.36	25.68	104.38	29.90
94	11.85	28.93	101.22	25.95	11.80	29.17	100.85	26.19
95	6.76	5.20	109.01	37.03	6.78	5.24	108.79	37.36
96	9.38	27.94	113.50	51.70	9.38	28.52	113.36	52.18
97	10.49	35.02	111.08	42.45	10.47	35.54	110.90	42.86
98	11.82	40.35	106.88	33.06	11.78	40.74	106.62	33.37
99	7.45	14.33	114.02	85.50	7.47	14.52	113.94	86.36
100	7.09	22.73	112.48	170.36	7.11	23.00	112.41	171.77
101	6.23	20.96	107.36	199.83	6.23	21.10	107.21	201.32
102	6.01	24.12	99.70	162.80	6.01	24.27	99.40	164.85
103	5.67	0.38	93.43	14.07	5.61	0.40	94.17	15.44
104	8.11	3.05	93.34	14.00	8.10	3.29	94.09	15.36
105	8.82	4.23	93.42	13.98	8.76	4.50	94.17	15.35
106	10.01	4.86	93.52	13.98	9.88	5.05	94.27	15.35
107	11.59	11.19	93.86	14.11	11.49	11.53	94.60	15.49
108	5.60	1.08	96.85	15.50	5.54	1.15	97.54	17.01
109	7.99	7.68	96.74	15.43	7.97	8.29	97.44	16.93
110	8.90	11.09	96.06	15.05	8.84	11.76	96.78	16.51
111	10.13	13.10	95.78	14.90	10.02	13.62	96.50	16.35
112	8.94	17.42	105.43	21.03	8.88	18.42	105.95	23.07
113	10.26	21.17	104.44	20.15	10.16	21.97	104.99	22.13
114	11.88	24.63	100.75	17.59	11.79	25.35	101.38	19.30
115	7.08	5.48	110.20	27.88	7.09	5.93	110.56	30.58
116	8.98	23.53	113.04	33.73	8.91	24.85	113.33	37.00
117	7.48	15.21	114.96	69.50	7.48	16.47	115.07	75.63
118	9.01	34.85	113.70	70.49	8.95	36.90	113.88	76.73
119	7.29	22.61	114.66	155.53	7.29	24.51	114.84	169.93
120	6.77	17.01	109.24	181.76	6.76	18.74	108.79	186.94
121	9.06	61.98	105.59	135.62	9.00	65.87	104.82	138.85
122	6.43	16.86	103.82	187.94	6.41	18.79	104.27	199.82
123	6.35	0.21	52.43	6.37	6.39	0.21	47.70	5.72
124	7.39	0.77	52.39	6.37	7.42	0.78	47.69	5.71
125	10.84	2.16	52.39	6.37	10.77	2.12	47.69	5.71
126	11.83	3.47	52.40	6.34	11.84	3.47	47.69	5.71
127	12.74	8.13	52.43	6.37	12.73	8.26	47.70	5.71
128	6.35	0.59	53.04	6.48	6.40	0.58	47.77	5.74
129	7.34	2.21	53.03	6.48	7.41	2.25	47.76	5.74
130	10.23	5.23	53.03	6.47	10.20	5.32	47.76	5.74
131	11.61	8.40	52.76	6.41	11.59	8.56	47.73	5.72
132	10.02	8.23	56.83	7.19	10.02	8.45	48.16	5.89
133	11.62	13.54	54.98	6.85	11.59	13.82	47.94	5.80
134	6.68	2.29	58.95	7.66	6.71	2.26	48.50	6.01
135	9.94	11.25	65.26	9.18	9.96	11.58	49.30	6.39
136	6.93	5.60	70.59	15.28	6.97	5.63	50.57	9.67
137	9.89	15.33	68.68	21.67	9.90	15.85	49.80	14.06
138	6.86	9.00	71.55	36.58	6.89	9.12	50.99	22.47

	Line7				Line8			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	4.88	0.27	85.41	14.77	4.92	0.25	85.06	13.28
2	8.13	2.89	85.32	14.70	8.15	2.69	84.97	13.22
3	8.84	3.98	85.34	14.67	8.93	3.78	84.99	13.20
4	9.87	4.31	85.40	14.67	10.04	4.20	85.04	13.20
5	11.42	8.80	85.93	14.87	11.56	8.61	85.58	13.38
6	4.68	0.74	90.35	16.94	4.71	0.68	90.03	15.23
7	8.05	7.13	90.25	16.84	8.07	6.60	89.93	15.13
8	8.66	9.49	89.10	16.23	8.74	8.95	88.77	14.60
9	9.78	10.35	88.55	15.98	9.94	10.01	88.22	14.37
10	8.64	14.49	101.72	24.35	8.72	13.65	101.48	21.86
11	9.93	16.46	100.26	22.97	10.10	15.91	100.01	20.62
12	7.37	4.56	108.03	33.94	7.40	4.16	107.88	30.43
13	7.73	12.92	114.28	96.69	7.75	11.90	114.19	85.93
14	8.71	27.85	112.58	99.57	8.78	26.23	112.42	88.29
15	7.63	16.81	114.07	274.39	7.66	15.46	114.03	241.11
16	5.90	0.41	91.19	29.40	5.90	0.41	92.00	28.96
17	8.27	2.96	91.12	29.25	8.26	2.88	91.94	28.82
18	8.93	4.13	91.19	29.22	8.94	4.01	92.02	28.81
19	9.61	4.28	91.27	29.22	9.66	4.19	92.10	28.78
20	5.87	1.18	93.30	31.37	5.87	1.17	94.09	30.93
21	8.15	6.89	93.38	31.32	8.12	6.67	94.18	30.86
22	8.90	10.31	93.55	31.33	8.89	9.90	94.35	30.89
23	8.94	16.19	102.73	42.75	8.92	15.52	103.36	42.17
24	6.78	4.67	105.12	48.53	6.75	4.61	105.96	47.22
25	8.97	21.78	111.21	68.64	8.96	20.86	111.60	67.77
26	7.34	11.50	112.39	128.90	7.30	11.24	112.69	127.20
27	9.06	32.85	112.92	192.19	9.04	31.40	113.25	189.62
28	7.04	15.15	110.64	364.80	7.00	14.88	110.91	359.61
29	6.26	10.37	104.91	659.75	6.25	10.30	105.21	649.46
30	4.94	0.30	94.75	18.69	4.88	0.31	96.51	19.93
31	8.14	3.18	94.67	18.59	8.10	3.27	96.44	19.84
32	8.74	4.27	94.75	18.58	8.70	4.36	96.53	19.82
33	9.64	4.47	94.85	18.58	9.59	4.52	96.64	19.82
34	11.15	8.94	95.17	18.80	11.17	9.14	96.94	20.04
35	4.73	0.82	98.01	20.90	4.68	0.87	99.62	22.32
36	8.06	7.80	97.92	20.78	8.02	8.08	99.54	22.17
37	8.59	10.24	97.28	20.20	8.53	10.47	98.95	21.56
38	9.56	10.81	97.02	19.96	9.52	10.98	98.72	21.30
39	8.58	15.66	106.27	28.83	8.52	16.01	107.45	30.75
40	9.71	17.18	105.35	27.47	9.67	17.48	106.60	29.39
41	11.66	19.91	101.81	23.77	11.69	20.42	103.26	25.39
42	7.38	4.97	110.74	38.74	7.34	5.27	111.57	41.40
43	8.59	20.80	113.46	47.13	8.53	21.25	114.14	50.59
44	9.88	23.70	112.76	43.91	9.84	24.13	113.47	46.92
45	7.73	14.03	115.37	110.35	7.69	14.72	115.76	119.25

46	8.67	30.23	114.49	116.58	8.62	30.73	115.08	126.06
47	7.64	18.11	114.92	316.57	7.58	19.07	115.28	345.51
48	6.39	0.22	48.32	4.96	6.36	0.22	55.20	5.77
49	7.65	0.90	48.29	4.96	7.78	0.98	55.12	5.77
50	10.58	2.13	48.30	4.96	10.49	2.22	55.15	5.77
51	11.80	3.39	48.30	4.96	11.71	3.40	55.16	5.77
52	12.77	7.99	48.32	4.96	12.74	7.85	55.21	5.77
53	6.40	0.60	48.51	5.01	6.36	0.61	56.15	5.93
54	7.51	2.44	48.51	5.01	7.58	2.57	56.13	5.93
55	10.07	5.16	48.54	5.01	10.01	5.20	56.26	5.93
56	11.59	8.21	48.46	4.98	11.55	8.08	55.84	5.86
57	9.89	8.09	50.08	5.30	9.83	8.05	62.55	6.98
58	11.60	13.19	49.46	5.19	11.57	12.95	59.88	6.52
59	13.01	17.70	48.78	5.05	13.01	17.41	57.12	6.07
60	6.73	2.33	50.57	5.46	6.73	2.37	64.83	7.47
61	9.83	11.02	53.84	6.22	9.76	10.91	74.20	9.64
62	11.65	18.42	52.19	5.77	11.63	18.10	68.96	8.31
63	6.99	5.82	55.39	9.60	7.01	5.89	78.58	15.98
64	9.75	15.13	55.92	14.29	9.71	14.99	78.51	23.49
65	5.57	0.40	89.92	12.18	5.63	0.38	89.57	11.06
66	8.02	3.06	89.84	12.12	8.03	2.82	89.48	11.01
67	8.73	4.16	89.88	12.11	8.79	3.89	89.52	10.99
68	9.98	4.77	89.96	12.10	10.13	4.58	89.60	10.99
69	11.69	11.25	90.53	12.29	11.79	10.90	90.17	11.15
70	5.50	1.15	95.29	14.13	5.56	1.08	94.96	12.83
71	7.89	7.85	95.20	14.06	7.89	7.24	94.86	12.76
72	8.78	10.95	94.03	13.53	8.85	10.28	93.69	12.29
73	10.09	12.94	93.49	13.30	10.22	12.42	93.14	12.07
74	8.81	17.27	105.96	20.81	8.88	16.23	105.72	18.88
75	10.23	20.93	104.73	19.67	10.34	20.11	104.47	17.85
76	11.98	24.84	100.30	16.61	12.07	24.07	100.01	15.07
77	7.04	5.88	110.92	28.91	7.03	5.42	110.77	26.25
78	8.84	23.30	113.51	35.19	8.91	21.95	113.39	31.96
79	10.34	28.99	112.74	32.65	10.46	27.89	112.61	29.65
80	11.95	34.64	109.72	26.28	12.04	33.61	109.54	23.85
81	7.41	16.13	115.25	74.73	7.40	14.85	115.22	68.31
82	7.22	24.22	115.11	167.73	7.22	22.33	115.04	152.89
83	5.90	0.47	98.08	23.75	5.90	0.47	98.81	23.46
84	8.46	3.64	98.05	23.65	8.44	3.55	98.79	23.35
85	9.09	5.39	98.17	23.64	9.09	5.23	98.91	23.34
86	9.91	5.94	98.29	23.65	9.95	5.80	99.03	23.35
87	11.49	13.28	98.38	23.69	11.59	13.10	99.12	23.40
88	5.87	1.36	99.82	24.95	5.87	1.36	100.52	24.63
89	8.36	8.25	99.93	24.95	8.33	8.01	100.63	24.64
90	9.28	13.42	100.15	25.07	9.28	13.00	100.86	24.75
91	10.22	15.81	99.47	24.47	10.27	15.41	100.19	24.15
92	9.34	20.77	107.51	33.54	9.34	20.12	108.04	33.15

93	10.38	25.34	104.78	29.80	10.43	24.71	105.38	29.45
94	11.85	29.00	101.31	26.10	11.94	28.64	101.99	25.78
95	6.76	5.21	109.10	37.24	6.73	5.15	109.55	36.81
96	9.38	27.97	113.58	52.02	9.38	27.04	113.89	51.45
97	10.49	35.04	111.17	42.72	10.54	34.17	111.56	42.26
98	11.83	40.45	106.98	33.27	11.91	39.90	107.50	32.89
99	7.45	14.36	114.10	86.08	7.41	14.05	114.31	85.04
100	7.08	22.83	112.54	171.14	7.04	22.44	112.73	169.35
101	6.23	21.11	107.34	200.46	6.22	20.95	107.54	198.40
102	6.01	24.32	99.51	164.18	6.01	24.18	99.74	161.58
103	5.56	0.42	95.67	16.57	5.50	0.44	97.46	17.52
104	8.08	3.45	95.60	16.49	8.05	3.57	97.40	17.44
105	8.71	4.67	95.68	16.47	8.66	4.78	97.49	17.42
106	9.78	5.16	95.79	16.49	9.73	5.22	97.61	17.42
107	11.45	11.79	96.11	16.63	11.45	12.01	97.92	17.58
108	5.48	1.22	98.93	18.26	5.43	1.28	100.57	19.30
109	7.94	8.73	98.84	18.19	7.90	9.10	100.48	19.22
110	8.77	12.16	98.21	17.72	8.71	12.42	99.91	18.74
111	9.95	13.92	97.95	17.56	9.89	14.11	99.68	18.56
112	8.81	19.04	106.97	24.78	8.74	19.42	108.15	26.23
113	10.09	22.44	106.07	23.78	10.04	22.74	107.32	25.17
114	11.77	25.92	102.62	20.73	11.78	26.41	104.08	21.93
115	7.08	6.33	111.27	32.86	7.07	6.71	112.08	34.77
116	8.83	25.68	113.89	39.76	8.76	26.17	114.49	42.02
117	7.45	17.55	115.35	80.79	7.42	18.50	115.68	85.04
118	8.89	38.06	114.37	82.04	8.82	38.76	115.04	87.10
119	7.26	26.27	115.15	180.60	7.23	27.90	115.49	189.09
120	6.75	20.46	109.76	198.82	6.74	22.14	110.40	206.80
121	8.92	68.15	106.61	147.21	8.85	69.43	107.82	154.39
122	6.39	20.72	104.95	205.88	6.39	22.57	105.23	205.93
123	6.39	0.21	48.10	5.66	6.35	0.22	53.53	6.27
124	7.57	0.86	48.09	5.66	7.71	0.96	53.47	6.27
125	10.60	2.13	48.09	5.66	10.38	2.16	53.49	6.26
126	11.79	3.49	48.10	5.66	11.73	3.52	53.51	6.26
127	12.71	8.44	48.11	5.66	12.70	8.64	53.54	6.27
128	6.40	0.58	48.22	5.68	6.35	0.61	54.24	6.39
129	7.53	2.42	48.21	5.68	7.64	2.63	54.23	6.39
130	10.13	5.49	48.25	5.68	10.04	5.69	54.33	6.39
131	11.55	8.77	48.19	5.68	11.51	9.00	54.01	6.35
132	9.99	8.78	49.27	5.92	9.94	9.12	59.30	7.25
133	11.56	14.19	48.86	5.83	11.52	14.57	57.18	6.88
134	6.74	2.29	49.56	6.03	6.73	2.36	61.19	7.65
135	9.95	12.03	51.93	6.64	9.91	12.50	69.61	9.55
136	7.02	5.80	52.66	9.85	7.05	6.07	73.49	15.11
137	9.88	16.57	52.76	14.61	9.84	17.32	72.80	21.90
138	6.91	9.46	51.56	21.88	6.91	9.91	71.88	33.16

	Line9				Line10			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.63	0.38	85.70	12.17	5.57	0.40	86.05	13.40
2	8.03	2.83	85.60	12.11	8.03	3.07	85.96	13.34
3	8.79	3.90	85.63	12.10	8.73	4.17	85.99	13.32
4	10.12	4.59	85.69	12.10	9.98	4.77	86.05	13.32
5	11.79	10.89	86.22	12.23	11.68	11.25	86.58	13.48
6	5.56	1.08	90.66	13.78	5.50	1.15	91.00	15.17
7	7.89	7.25	90.55	13.71	7.89	7.87	90.89	15.10
8	8.85	10.30	89.41	13.26	8.78	10.97	89.76	14.60
9	10.21	12.42	88.86	13.08	10.09	12.94	89.21	14.40
10	8.88	16.24	101.95	19.49	8.81	17.26	102.22	21.46
11	10.34	20.11	100.49	18.50	10.22	20.93	100.78	20.37
12	7.03	5.42	108.24	26.64	7.04	5.88	108.44	29.32
13	7.40	14.86	114.29	68.23	7.41	16.13	114.33	74.60
14	8.95	32.19	112.47	68.14	8.89	34.27	112.53	74.37
15	7.22	22.38	114.10	152.41	7.22	24.29	114.19	167.10
16	6.36	0.22	53.07	6.35	6.39	0.21	47.91	5.67
17	7.79	0.99	53.02	6.33	7.66	0.90	47.90	5.65
18	10.48	2.22	53.02	6.33	10.57	2.13	47.90	5.65
19	11.71	3.40	53.02	6.33	11.79	3.39	47.90	5.65
20	6.36	0.60	53.87	6.49	6.40	0.59	48.07	5.70
21	7.59	2.58	53.86	6.47	7.52	2.44	48.06	5.70
22	10.01	5.21	53.93	6.49	10.07	5.17	48.09	5.70
23	9.83	8.06	59.28	7.45	9.89	8.10	49.30	5.97
24	6.73	2.37	61.52	7.93	6.73	2.33	49.79	6.11
25	9.76	10.92	70.18	9.96	9.82	11.04	52.46	6.80
26	7.01	5.88	75.20	16.41	7.00	5.81	54.18	10.34
27	9.71	15.04	74.49	23.91	9.75	15.18	54.22	15.30
28	6.90	9.26	75.44	39.08	6.90	9.35	54.73	24.07
29	6.72	6.59	67.27	63.31	6.74	6.77	51.74	42.33
30	4.88	0.31	96.52	19.93	4.94	0.30	94.77	18.69
31	8.10	3.27	96.44	19.83	8.14	3.18	94.68	18.59
32	8.70	4.36	96.53	19.80	8.74	4.28	94.76	18.58
33	9.59	4.52	96.64	19.82	9.64	4.47	94.86	18.58
34	11.17	9.14	96.94	20.04	11.15	8.94	95.18	18.80
35	4.68	0.87	99.62	22.32	4.73	0.82	98.01	20.90
36	8.02	8.08	99.55	22.17	8.06	7.80	97.93	20.78
37	8.53	10.47	98.95	21.56	8.59	10.25	97.28	20.20
38	9.52	10.98	98.71	21.29	9.56	10.81	97.03	19.96
39	8.52	16.01	107.44	30.75	8.58	15.67	106.27	28.83
40	9.67	17.48	106.59	29.38	9.71	17.18	105.35	27.47
41	11.69	20.42	103.25	25.39	11.66	19.91	101.82	23.75
42	7.34	5.28	111.56	41.40	7.38	4.97	110.75	38.73
43	8.53	21.27	114.13	50.59	8.59	20.80	113.47	47.13
44	9.84	24.14	113.46	46.92	9.88	23.71	112.77	43.89
45	7.69	14.72	115.75	119.24	7.73	14.04	115.38	110.35

46	8.62	30.74	115.08	126.06	8.67	30.23	114.50	116.58
47	7.58	19.07	115.27	345.53	7.64	18.12	114.92	316.57
48	5.90	0.41	97.56	28.07	5.90	0.41	96.85	28.48
49	8.26	2.89	97.52	27.93	8.27	2.97	96.81	28.34
50	8.94	4.03	97.63	27.92	8.93	4.15	96.91	28.33
51	9.66	4.20	97.74	27.91	9.60	4.29	97.02	28.33
52	11.38	8.99	97.84	28.04	11.23	9.10	97.13	28.45
53	5.87	1.18	99.45	30.07	5.87	1.18	98.77	30.50
54	8.12	6.69	99.55	30.03	8.15	6.91	98.87	30.45
55	8.89	9.93	99.75	30.04	8.90	10.33	99.07	30.48
56	9.70	10.74	99.01	29.17	9.65	11.09	98.31	29.60
57	8.92	15.54	107.42	41.49	8.94	16.20	106.91	42.06
58	9.87	17.52	104.57	36.33	9.82	18.09	104.32	36.15
59	11.81	20.54	100.95	31.38	11.66	20.76	100.29	31.83
60	6.75	4.62	109.16	47.24	6.78	4.68	108.72	47.88
61	8.95	20.87	113.72	67.22	8.97	21.77	113.43	68.10
62	10.02	24.42	111.21	53.76	9.96	25.19	110.83	54.46
63	7.30	11.27	114.13	126.28	7.34	11.53	113.90	128.00
64	9.04	31.41	115.01	187.94	9.06	32.85	114.75	190.52
65	4.92	0.25	88.85	11.98	4.88	0.27	89.23	13.32
66	8.16	2.69	88.77	11.93	8.14	2.90	89.15	13.25
67	8.92	3.79	88.80	11.91	8.83	3.99	89.18	13.24
68	10.04	4.20	88.86	11.91	9.87	4.32	89.25	13.24
69	11.55	8.60	89.45	12.11	11.41	8.79	89.82	13.45
70	4.71	0.68	94.31	14.09	4.68	0.74	94.62	15.67
71	8.07	6.61	94.23	14.00	8.05	7.14	94.54	15.56
72	8.74	8.96	93.02	13.43	8.65	9.51	93.35	14.93
73	9.94	10.01	92.47	13.18	9.77	10.35	92.81	14.65
74	8.72	13.66	105.28	21.03	8.64	14.50	105.49	23.43
75	10.09	15.90	104.01	19.76	9.93	16.46	104.23	22.01
76	12.05	19.17	99.46	16.57	11.91	19.59	99.74	18.43
77	7.40	4.16	110.45	29.77	7.38	4.56	110.57	33.19
78	8.73	18.13	113.17	36.33	8.65	19.26	113.23	40.71
79	10.26	22.01	112.34	33.47	10.10	22.76	112.45	37.31
80	12.07	27.00	109.22	26.62	11.94	27.59	109.37	29.66
81	7.76	11.91	115.11	85.14	7.73	12.95	115.18	95.74
82	7.67	15.50	114.95	238.46	7.63	16.88	114.99	271.25
83	6.35	0.22	55.53	5.55	6.39	0.21	48.39	4.85
84	7.71	0.97	55.46	5.55	7.58	0.87	48.38	4.83
85	10.38	2.17	55.48	5.54	10.59	2.14	48.38	4.83
86	11.72	3.52	55.51	5.54	11.79	3.49	48.39	4.83
87	12.70	8.65	55.57	5.55	12.71	8.44	48.40	4.83
88	6.35	0.61	56.45	5.69	6.40	0.59	48.57	4.87
89	7.64	2.64	56.45	5.69	7.53	2.44	48.57	4.87
90	10.02	5.70	56.55	5.69	10.12	5.50	48.60	4.87
91	11.50	9.01	56.18	5.63	11.55	8.78	48.53	4.85
92	9.94	9.14	62.70	6.63	9.98	8.79	49.98	5.13

93	11.52	14.59	60.12	6.23	11.55	14.20	49.45	5.04
94	12.90	19.15	57.45	5.82	12.92	18.72	48.84	4.91
95	6.73	2.39	64.97	7.08	6.74	2.30	50.44	5.28
96	9.91	12.53	74.17	9.04	9.94	12.06	53.35	5.93
97	11.58	20.38	69.04	7.87	11.60	19.87	51.96	5.57
98	12.85	26.80	62.80	6.68	12.87	26.23	50.22	5.18
99	7.05	6.09	78.18	14.56	7.03	5.83	54.43	8.97
100	6.92	9.97	77.00	31.81	6.92	9.52	53.56	19.82
101	6.71	7.62	66.98	46.14	6.75	7.08	49.74	33.03
102	6.64	7.22	57.05	55.94	6.67	6.47	46.98	47.12
103	5.50	0.44	97.47	17.52	5.56	0.42	95.67	16.57
104	8.05	3.57	97.41	17.44	8.08	3.45	95.60	16.49
105	8.66	4.78	97.50	17.42	8.71	4.67	95.68	16.47
106	9.73	5.22	97.62	17.42	9.79	5.16	95.79	16.47
107	11.45	12.01	97.93	17.58	11.45	11.79	96.12	16.63
108	5.43	1.28	100.57	19.30	5.48	1.22	98.93	18.25
109	7.90	9.08	100.49	19.22	7.94	8.74	98.84	18.19
110	8.71	12.43	99.92	18.73	8.77	12.16	98.21	17.72
111	9.89	14.11	99.69	18.56	9.95	13.92	97.96	17.56
112	8.74	19.43	108.17	26.23	8.81	19.04	106.98	24.78
113	10.03	22.75	107.33	25.16	10.09	22.45	106.07	23.78
114	11.78	26.41	104.09	21.93	11.77	25.92	102.62	20.73
115	7.07	6.72	112.09	34.77	7.08	6.34	111.27	32.85
116	8.76	26.18	114.51	42.02	8.83	25.66	113.89	39.76
117	7.42	18.52	115.70	85.03	7.45	17.55	115.35	80.80
118	8.82	38.74	115.06	87.10	8.89	38.09	114.36	82.04
119	7.23	27.90	115.51	189.08	7.26	26.28	115.14	180.62
120	6.74	22.13	110.42	206.72	6.75	20.46	109.74	198.81
121	8.85	69.48	107.87	154.24	8.93	68.19	106.59	147.12
122	6.39	22.54	105.23	205.51	6.39	20.67	104.86	205.67
123	5.90	0.47	93.13	24.08	5.90	0.47	92.30	24.39
124	8.45	3.55	93.06	23.96	8.46	3.65	92.23	24.29
125	9.09	5.26	93.16	23.96	9.09	5.40	92.32	24.27
126	9.94	5.81	93.26	23.98	9.90	5.96	92.42	24.28
127	11.58	13.10	93.35	24.01	11.50	13.28	92.51	24.32
128	5.87	1.36	95.04	25.22	5.87	1.36	94.24	25.55
129	8.33	8.02	95.13	25.22	8.36	8.26	94.33	25.54
130	9.29	13.01	95.33	25.32	9.28	13.42	94.53	25.64
131	10.27	15.41	94.54	24.74	10.23	15.79	93.72	25.07
132	9.34	20.10	103.90	33.54	9.34	20.77	103.27	33.94
133	10.43	24.71	100.67	29.90	10.38	25.32	99.96	30.27
134	6.73	5.16	106.00	37.14	6.75	5.22	105.45	37.59
135	9.38	27.04	111.71	51.64	9.38	27.97	111.33	52.23
136	7.40	14.07	112.81	85.14	7.44	14.38	112.56	86.20
137	9.30	41.58	113.46	117.90	9.31	43.15	113.17	119.24
138	7.04	22.51	111.26	168.78	7.08	22.88	111.05	170.73

	Line11				Line11			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.53	0.42	86.35	14.51	5.49	0.44	87.47	15.40
2	8.02	3.29	86.26	14.45	8.01	3.45	87.38	15.33
3	8.68	4.42	86.29	14.43	8.64	4.58	87.42	15.32
4	9.85	4.95	86.35	14.43	9.77	5.07	87.48	15.31
5	11.58	11.58	86.89	14.60	11.55	11.85	88.01	15.48
6	5.46	1.22	91.30	16.42	5.41	1.28	92.36	17.44
7	7.88	8.43	91.19	16.35	7.86	8.85	92.26	17.36
8	8.73	11.59	90.06	15.82	8.68	11.99	91.15	16.78
9	9.99	13.43	89.51	15.59	9.92	13.75	90.61	16.55
10	8.76	18.19	102.45	23.26	8.70	18.81	103.27	24.72
11	10.13	21.69	101.02	22.07	10.06	22.19	101.88	23.47
12	7.05	6.30	108.60	31.75	7.04	6.69	109.16	33.75
13	7.40	17.30	114.35	80.24	7.39	18.31	114.56	84.89
14	8.84	36.17	112.57	80.04	8.78	37.34	112.92	84.58
15	7.22	26.06	114.27	180.33	7.20	27.71	114.51	190.29
16	6.38	0.22	47.88	5.67	6.34	0.23	52.93	6.25
17	7.45	0.82	47.87	5.66	7.30	0.78	52.89	6.25
18	10.67	2.05	47.88	5.66	10.67	2.02	52.90	6.24
19	11.87	3.39	47.88	5.66	11.89	3.41	52.92	6.24
20	6.39	0.60	47.93	5.69	6.34	0.63	53.47	6.35
21	7.40	2.32	47.93	5.69	7.33	2.30	53.47	6.33
22	10.13	5.16	47.93	5.69	10.13	5.25	53.49	6.33
23	9.95	8.19	48.31	5.83	9.97	8.41	57.07	7.00
24	6.70	2.32	48.55	5.94	6.66	2.39	58.88	7.38
25	9.88	11.21	49.38	6.32	9.90	11.55	64.98	8.80
26	6.96	5.81	50.18	9.37	6.93	5.96	69.36	14.08
27	9.80	15.36	49.80	13.67	9.82	15.79	67.80	19.89
28	6.87	9.58	49.93	20.97	6.83	9.94	68.86	31.00
29	6.72	7.17	48.28	36.69	6.67	7.75	61.94	47.00
30	5.02	0.28	93.31	17.24	5.08	0.26	92.60	15.54
31	8.17	3.05	93.21	17.16	8.19	2.85	92.50	15.47
32	8.79	4.15	93.28	17.14	8.86	3.96	92.57	15.44
33	9.73	4.40	93.38	17.14	9.88	4.29	92.66	15.45
34	11.19	8.76	93.71	17.33	11.33	8.59	93.00	15.62
35	4.79	0.77	96.67	19.27	4.84	0.71	96.02	17.34
36	8.09	7.44	96.58	19.13	8.12	6.94	95.92	17.24
37	8.65	9.91	95.89	18.61	8.72	9.40	95.22	16.76
38	9.65	10.58	95.62	18.39	9.79	10.25	94.94	16.58
39	8.64	15.15	105.27	26.51	8.71	14.34	104.72	24.03
40	9.80	16.81	104.30	25.27	9.94	16.27	103.79	22.74
41	11.70	19.47	100.61	21.88	11.83	19.07	100.02	19.70
42	7.41	4.64	110.05	35.74	7.44	4.25	109.71	32.21
43	8.66	20.11	112.92	43.40	8.73	19.04	112.65	39.16
44	9.96	23.19	112.17	40.47	10.11	22.45	111.88	36.47
45	7.78	13.22	115.05	100.41	7.81	12.23	114.88	89.35

46	8.72	29.34	113.98	105.97	8.78	27.78	113.70	94.15
47	7.69	17.01	114.63	285.02	7.73	15.72	114.51	250.68
48	5.91	0.41	96.37	28.61	5.90	0.41	96.76	28.30
49	8.28	3.02	96.32	28.46	8.27	2.97	96.72	28.15
50	8.92	4.22	96.43	28.45	8.93	4.15	96.83	28.13
51	9.58	4.35	96.53	28.45	9.61	4.29	96.94	28.12
52	11.14	9.16	96.64	28.56	11.22	9.09	97.04	28.25
53	5.87	1.18	98.31	30.62	5.87	1.17	98.68	30.28
54	8.17	7.03	98.41	30.58	8.16	6.90	98.79	30.24
55	8.91	10.57	98.60	30.60	8.90	10.34	98.98	30.27
56	9.63	11.32	97.83	29.73	9.65	11.11	98.22	29.39
57	8.95	16.60	106.56	42.19	8.94	16.22	106.82	41.73
58	9.79	18.45	103.26	37.63	9.82	18.12	103.90	36.54
59	11.57	20.88	99.84	31.96	11.64	20.73	100.20	31.61
60	6.80	4.71	108.42	48.03	6.78	4.66	108.64	47.50
61	8.99	22.33	113.21	68.29	8.98	21.82	113.35	67.52
62	9.93	25.67	110.56	54.61	9.96	25.22	110.74	53.98
63	7.36	11.67	113.74	128.35	7.34	11.51	113.84	126.86
64	9.07	33.73	114.58	191.01	9.06	32.93	114.70	188.66
65	4.86	0.29	89.53	14.57	4.82	0.31	90.62	15.57
66	8.12	3.08	89.45	14.49	8.09	3.21	90.55	15.50
67	8.76	4.18	89.48	14.47	8.71	4.31	90.58	15.47
68	9.73	4.43	89.55	14.47	9.65	4.51	90.66	15.47
69	11.29	8.98	90.12	14.70	11.26	9.19	91.22	15.73
70	4.66	0.80	94.88	17.14	4.63	0.86	95.87	18.36
71	8.03	7.62	94.80	17.03	8.00	7.97	95.80	18.23
72	8.59	10.00	93.62	16.33	8.54	10.34	94.65	17.49
73	9.64	10.69	93.09	16.02	9.57	10.94	94.14	17.15
74	8.57	15.28	105.66	25.65	8.52	15.81	106.35	27.54
75	9.80	17.00	104.42	24.08	9.73	17.42	105.16	25.84
76	11.80	20.04	99.96	20.16	11.77	20.55	100.84	21.61
77	7.35	4.93	110.90	35.55	7.32	5.26	111.13	38.95
78	8.59	20.29	113.32	44.44	8.53	20.99	113.67	47.66
79	9.97	23.50	112.55	40.90	9.90	24.08	112.94	43.82
80	11.83	28.22	109.50	32.49	11.79	28.92	110.01	34.90
81	7.70	13.90	115.24	105.84	7.67	14.68	115.45	114.71
82	7.60	18.12	115.02	302.77	7.56	19.18	115.20	331.01
83	6.39	0.21	48.01	4.89	6.35	0.21	54.47	5.68
84	7.43	0.78	48.01	4.89	7.39	0.77	54.42	5.66
85	10.77	2.13	48.01	4.89	10.83	2.16	54.44	5.66
86	11.83	3.47	48.01	4.89	11.83	3.47	54.45	5.66
87	12.72	8.26	48.01	4.89	12.74	8.14	54.48	5.66
88	6.40	0.58	48.11	4.92	6.35	0.60	55.23	5.79
89	7.41	2.26	48.10	4.92	7.34	2.22	55.22	5.79
90	10.20	5.33	48.10	4.92	10.23	5.24	55.26	5.79
91	11.59	8.57	48.05	4.90	11.61	8.41	54.90	5.72
92	10.02	8.47	48.71	5.10	10.02	8.25	60.00	6.59

93	11.59	13.84	48.38	5.01	11.61	13.56	57.68	6.20
94	12.95	18.35	48.14	4.94	12.98	18.10	55.69	5.86
95	6.71	2.27	49.11	5.23	6.68	2.30	62.33	7.08
96	9.95	11.60	50.33	5.68	9.94	11.27	69.56	8.75
97	11.64	19.37	49.31	5.36	11.66	18.99	64.38	7.54
98	12.90	25.75	48.56	5.09	12.93	25.43	59.34	6.52
99	6.98	5.67	51.87	8.76	6.93	5.63	74.71	14.73
100	6.89	9.20	52.82	20.46	6.86	9.08	75.88	35.43
101	6.74	6.71	51.22	36.49	6.70	6.58	69.65	57.77
102	6.66	5.97	48.97	53.41	6.61	5.75	62.91	77.22
103	5.61	0.40	94.17	15.43	5.67	0.38	93.42	14.07
104	8.10	3.29	94.08	15.36	8.11	3.05	93.33	14.00
105	8.76	4.50	94.16	15.34	8.82	4.23	93.40	13.98
106	9.88	5.05	94.26	15.35	10.01	4.86	93.50	13.98
107	11.48	11.53	94.60	15.49	11.59	11.19	93.84	14.11
108	5.54	1.15	97.53	17.01	5.60	1.08	96.83	15.50
109	7.97	8.29	97.43	16.93	7.99	7.69	96.73	15.43
110	8.84	11.75	96.77	16.51	8.90	11.09	96.04	15.05
111	10.02	13.62	96.50	16.35	10.13	13.11	95.77	14.90
112	8.88	18.42	105.94	23.07	8.94	17.43	105.41	21.03
113	10.16	21.97	104.98	22.13	10.26	21.17	104.42	20.16
114	11.79	25.35	101.37	19.30	11.88	24.63	100.73	17.59
115	7.09	5.93	110.55	30.59	7.08	5.48	110.16	27.89
116	8.91	24.84	113.31	37.01	8.98	23.52	113.00	33.74
117	7.48	16.47	115.05	75.63	7.48	15.21	114.92	69.52
118	8.95	36.89	113.86	76.74	9.01	34.87	113.67	70.51
119	7.29	24.52	114.81	169.98	7.29	22.63	114.60	155.59
120	6.76	18.72	108.73	187.06	6.77	16.99	109.12	181.94
121	9.00	65.91	104.74	138.90	9.06	62.02	105.45	135.74
122	6.41	18.73	104.08	199.76	6.43	16.81	103.53	187.87
123	5.90	0.47	91.73	24.50	5.90	0.47	92.09	24.26
124	8.47	3.70	91.67	24.38	8.46	3.64	92.03	24.14
125	9.09	5.48	91.75	24.38	9.09	5.38	92.11	24.14
126	9.89	6.03	91.84	24.39	9.90	5.95	92.20	24.15
127	11.44	13.37	91.94	24.42	11.49	13.25	92.30	24.18
128	5.87	1.36	93.70	25.65	5.87	1.35	94.04	25.40
129	8.37	8.38	93.79	25.65	8.36	8.24	94.14	25.40
130	9.28	13.66	93.98	25.75	9.28	13.41	94.33	25.50
131	10.20	16.01	93.16	25.17	10.22	15.77	93.51	24.92
132	9.34	21.15	102.84	34.07	9.35	20.75	103.11	33.74
133	10.36	25.68	99.47	30.39	10.38	25.31	99.77	30.08
134	6.78	5.24	105.07	37.72	6.76	5.20	105.31	37.38
135	9.38	28.50	111.07	52.40	9.38	27.95	111.22	51.92
136	7.47	14.53	112.38	86.47	7.45	14.35	112.47	85.61
137	9.31	44.05	112.96	119.64	9.31	43.10	113.09	118.60
138	7.10	23.05	110.91	171.49	7.08	22.77	111.03	170.25

	Line13				Line14			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.49	0.44	87.46	15.40	5.53	0.42	86.34	14.51
2	8.01	3.45	87.38	15.32	8.02	3.29	86.25	14.45
3	8.64	4.58	87.41	15.31	8.68	4.42	86.28	14.43
4	9.77	5.07	87.48	15.31	9.85	4.95	86.34	14.43
5	11.55	11.85	88.01	15.48	11.58	11.58	86.88	14.59
6	5.42	1.28	92.36	17.42	5.46	1.22	91.28	16.42
7	7.86	8.85	92.26	17.35	7.88	8.43	91.18	16.34
8	8.68	11.99	91.14	16.78	8.73	11.61	90.04	15.81
9	9.92	13.75	90.61	16.55	9.99	13.43	89.50	15.59
10	8.70	18.82	103.29	24.71	8.76	18.21	102.46	23.25
11	10.06	22.19	101.89	23.45	10.13	21.69	101.02	22.07
12	7.04	6.69	109.18	33.74	7.05	6.30	108.60	31.75
13	7.39	18.32	114.59	84.86	7.40	17.31	114.36	80.22
14	8.79	37.33	112.94	84.56	8.84	36.19	112.57	80.02
15	7.20	27.71	114.52	190.21	7.22	26.08	114.26	180.27
16	5.90	0.47	92.25	24.28	5.90	0.47	91.82	24.51
17	8.46	3.64	92.19	24.16	8.47	3.70	91.76	24.41
18	9.09	5.39	92.28	24.16	9.09	5.49	91.85	24.39
19	9.91	5.94	92.36	24.17	9.89	6.03	91.93	24.40
20	5.87	1.36	94.19	25.42	5.87	1.36	93.78	25.66
21	8.36	8.24	94.28	25.41	8.37	8.38	93.87	25.66
22	9.28	13.42	94.48	25.52	9.28	13.67	94.07	25.76
23	9.35	20.75	103.20	33.74	9.34	21.15	102.90	34.07
24	6.76	5.20	105.38	37.38	6.77	5.24	105.11	37.73
25	9.38	27.95	111.26	51.90	9.38	28.51	111.09	52.38
26	7.45	14.35	112.50	85.61	7.47	14.54	112.40	86.47
27	9.31	43.10	113.10	118.50	9.31	44.07	112.97	119.58
28	7.08	22.79	111.02	169.90	7.10	23.06	110.91	171.28
29	6.23	21.08	105.35	199.42	6.23	21.24	105.17	200.89
30	5.67	0.38	93.43	14.07	5.61	0.40	94.17	15.44
31	8.11	3.05	93.34	14.00	8.10	3.29	94.09	15.36
32	8.82	4.23	93.42	13.98	8.76	4.50	94.17	15.35
33	10.01	4.86	93.52	13.98	9.88	5.05	94.27	15.35
34	11.59	11.19	93.86	14.11	11.49	11.53	94.60	15.49
35	5.60	1.08	96.85	15.50	5.54	1.15	97.54	17.01
36	7.99	7.68	96.74	15.43	7.97	8.29	97.44	16.93
37	8.90	11.09	96.06	15.05	8.84	11.76	96.78	16.51
38	10.13	13.11	95.78	14.90	10.02	13.62	96.51	16.35
39	8.94	17.42	105.43	21.03	8.88	18.42	105.96	23.07
40	10.26	21.18	104.44	20.15	10.16	21.97	104.99	22.13
41	11.88	24.63	100.75	17.59	11.79	25.35	101.38	19.30
42	7.08	5.48	110.19	27.88	7.09	5.93	110.56	30.58
43	8.98	23.52	113.03	33.73	8.91	24.85	113.33	37.00
44	10.38	29.34	112.26	31.70	10.28	30.41	112.58	34.80
45	7.48	15.21	114.95	69.50	7.48	16.47	115.07	75.63

46	9.01	34.85	113.70	70.49	8.95	36.90	113.88	76.73
47	7.29	22.61	114.65	155.55	7.29	24.53	114.83	169.95
48	6.35	0.21	53.86	5.65	6.39	0.21	47.84	4.93
49	7.39	0.77	53.82	5.65	7.42	0.78	47.84	4.92
50	10.83	2.16	53.82	5.63	10.77	2.12	47.84	4.91
51	11.83	3.47	53.83	5.63	11.84	3.47	47.84	4.91
52	12.74	8.13	53.86	5.65	12.73	8.26	47.84	4.91
53	6.35	0.59	54.62	5.77	6.40	0.58	47.93	4.96
54	7.34	2.21	54.61	5.77	7.41	2.25	47.93	4.96
55	10.23	5.23	54.63	5.77	10.21	5.32	47.92	4.94
56	11.61	8.40	54.28	5.70	11.59	8.56	47.88	4.93
57	10.02	8.23	59.32	6.56	10.02	8.45	48.46	5.12
58	11.61	13.54	57.03	6.18	11.59	13.82	48.16	5.05
59	12.98	18.08	55.08	5.83	12.95	18.33	47.95	4.96
60	6.68	2.29	61.76	7.07	6.71	2.26	48.89	5.27
61	9.94	11.25	68.69	8.70	9.96	11.58	49.87	5.70
62	11.66	18.97	63.67	7.50	11.64	19.35	48.98	5.37
63	6.93	5.60	74.10	14.69	6.97	5.64	51.38	8.78
64	9.89	15.33	72.41	20.69	9.90	15.85	50.51	12.58
65	4.82	0.31	90.65	15.57	4.86	0.29	89.56	14.57
66	8.09	3.21	90.57	15.50	8.12	3.08	89.47	14.49
67	8.71	4.31	90.61	15.47	8.76	4.18	89.51	14.47
68	9.65	4.51	90.69	15.47	9.73	4.43	89.58	14.47
69	11.25	9.19	91.25	15.73	11.29	8.98	90.15	14.70
70	4.63	0.86	95.91	18.36	4.66	0.80	94.91	17.14
71	8.00	7.97	95.83	18.23	8.03	7.62	94.83	17.03
72	8.54	10.34	94.69	17.49	8.59	10.00	93.65	16.33
73	9.57	10.94	94.17	17.15	9.64	10.69	93.11	16.02
74	8.52	15.81	106.38	27.55	8.57	15.29	105.69	25.65
75	9.73	17.42	105.20	25.85	9.80	17.01	104.46	24.09
76	11.77	20.55	100.88	21.61	11.80	20.04	100.00	20.16
77	7.32	5.26	111.17	38.95	7.35	4.93	110.84	35.89
78	8.53	21.00	113.71	47.64	8.59	20.29	113.34	44.44
79	9.90	24.08	112.98	43.83	9.97	23.50	112.58	40.92
80	11.79	28.93	110.06	34.90	11.82	28.22	109.53	32.49
81	7.67	14.69	115.50	114.72	7.70	13.91	115.27	105.87
82	7.56	19.19	115.27	331.05	7.60	18.13	115.08	302.84
83	5.90	0.41	96.55	28.26	5.91	0.41	96.26	28.60
84	8.27	2.97	96.52	28.11	8.28	3.02	96.22	28.45
85	8.93	4.15	96.62	28.11	8.92	4.22	96.32	28.43
86	9.61	4.30	96.72	28.10	9.58	4.35	96.42	28.42
87	11.21	9.08	96.83	28.23	11.14	9.16	96.53	28.55
88	5.87	1.18	98.49	30.26	5.87	1.18	98.21	30.61
89	8.16	6.90	98.59	30.21	8.17	7.03	98.31	30.57
90	8.90	10.33	98.79	30.23	8.91	10.57	98.50	30.58
91	9.65	11.11	98.02	29.35	9.63	11.31	97.73	29.70
92	8.94	16.22	106.69	41.70	8.95	16.60	106.50	42.18

93	9.82	18.10	103.74	36.52	9.79	18.44	103.18	37.61
94	11.64	20.73	100.01	31.57	11.57	20.88	99.74	31.95
95	6.78	4.67	108.53	47.45	6.80	4.71	108.36	48.02
96	8.98	21.82	113.28	67.47	8.99	22.33	113.18	68.26
97	9.96	25.22	110.65	53.95	9.93	25.66	110.52	54.59
98	11.62	29.22	106.12	41.10	11.55	29.45	105.93	41.60
99	7.34	11.51	113.80	126.76	7.36	11.67	113.73	128.32
100	7.04	15.19	112.01	357.61	7.06	15.36	111.94	362.53
101	6.26	10.36	106.83	643.87	6.26	10.41	106.70	653.81
102	6.09	9.25	98.97	866.50	6.09	9.28	98.68	880.02
103	5.07	0.26	92.57	15.55	5.02	0.28	93.29	17.24
104	8.19	2.86	92.48	15.47	8.17	3.05	93.20	17.16
105	8.86	3.96	92.55	15.46	8.79	4.15	93.27	17.14
106	9.88	4.29	92.64	15.46	9.73	4.40	93.36	17.13
107	11.33	8.59	92.97	15.62	11.19	8.76	93.69	17.32
108	4.84	0.71	95.99	17.34	4.79	0.77	96.65	19.27
109	8.12	6.93	95.89	17.25	8.09	7.43	96.56	19.15
110	8.72	9.40	95.20	16.77	8.65	9.91	95.88	18.61
111	9.79	10.24	94.91	16.57	9.65	10.58	95.60	18.39
112	8.71	14.34	104.61	24.20	8.64	15.15	105.25	26.51
113	9.94	16.26	103.76	22.75	9.80	16.81	104.29	25.28
114	11.83	19.07	100.00	19.69	11.70	19.48	100.59	21.88
115	7.44	4.25	109.68	32.21	7.42	4.64	110.03	35.74
116	8.73	19.03	112.61	39.16	8.66	20.11	112.89	43.40
117	7.81	12.23	114.83	89.36	7.78	13.22	115.02	100.41
118	8.78	27.77	113.66	94.17	8.72	29.33	113.95	105.97
119	7.73	15.72	114.46	250.71	7.69	17.01	114.61	285.02
120	7.05	9.25	109.05	406.53	7.01	10.04	109.28	467.05
121	8.97	44.64	105.37	308.49	8.90	46.95	105.78	354.35
122	6.27	6.73	103.50	572.06	6.24	7.32	103.89	665.30
123	6.34	0.23	52.69	6.26	6.38	0.22	47.74	5.71
124	7.30	0.78	52.66	6.25	7.44	0.82	47.74	5.71
125	10.65	2.01	52.67	6.25	10.67	2.05	47.74	5.69
126	11.89	3.41	52.69	6.25	11.87	3.39	47.74	5.69
127	12.83	8.46	52.71	6.24	12.80	8.20	47.75	5.69
128	6.34	0.63	53.23	6.35	6.39	0.60	47.79	5.72
129	7.33	2.30	53.24	6.35	7.39	2.31	47.79	5.72
130	10.12	5.24	53.25	6.34	10.13	5.16	47.79	5.71
131	11.64	8.62	53.01	6.31	11.63	8.39	47.77	5.71
132	9.96	8.41	56.74	6.99	9.95	8.19	48.12	5.86
133	11.63	13.94	55.04	6.67	11.63	13.52	47.94	5.79
134	6.66	2.40	58.65	7.38	6.70	2.33	48.38	5.96
135	9.90	11.54	64.53	8.75	9.88	11.20	49.03	6.31
136	6.93	5.96	68.90	14.04	6.96	5.82	49.74	9.38
137	9.82	15.78	66.64	19.59	9.80	15.33	48.95	13.62
138	6.84	9.98	68.01	30.82	6.86	9.66	49.11	21.02

	Line15				Line16			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.57	0.40	86.03	13.40	5.63	0.38	85.67	12.18
2	8.03	3.07	85.94	13.34	8.03	2.83	85.58	12.11
3	8.73	4.17	85.97	13.32	8.79	3.90	85.60	12.10
4	9.97	4.77	86.03	13.32	10.13	4.59	85.66	12.10
5	11.68	11.25	86.57	13.48	11.79	10.89	86.20	12.23
6	5.50	1.15	90.98	15.17	5.56	1.08	90.62	13.78
7	7.89	7.87	90.88	15.08	7.89	7.25	90.52	13.71
8	8.78	10.97	89.73	14.60	8.85	10.30	89.37	13.26
9	10.09	12.94	89.19	14.40	10.21	12.42	88.83	13.07
10	8.81	17.27	102.22	21.46	8.88	16.25	101.93	19.49
11	10.22	20.94	100.76	20.37	10.34	20.11	100.46	18.50
12	7.04	5.88	108.42	29.32	7.03	5.42	108.21	26.64
13	7.41	16.14	114.31	74.58	7.40	14.87	114.25	68.23
14	8.89	34.27	112.51	74.35	8.95	32.20	112.43	68.14
15	7.22	24.31	114.16	167.06	7.22	22.38	114.03	152.40
16	5.90	0.47	92.31	24.41	5.90	0.47	93.06	24.07
17	8.46	3.65	92.25	24.29	8.45	3.55	93.00	23.97
18	9.09	5.40	92.34	24.28	9.09	5.24	93.10	23.95
19	9.91	5.95	92.43	24.28	9.94	5.82	93.19	23.96
20	5.87	1.37	94.26	25.54	5.87	1.36	94.98	25.21
21	8.36	8.26	94.35	25.54	8.33	8.02	95.08	25.21
22	9.28	13.43	94.55	25.65	9.29	13.01	95.28	25.31
23	9.34	20.78	103.29	33.94	9.34	20.11	103.88	33.55
24	6.75	5.22	105.47	37.59	6.73	5.15	105.99	37.15
25	9.38	27.98	111.34	52.22	9.38	27.06	111.70	51.64
26	7.44	14.39	112.58	86.19	7.40	14.06	112.82	85.14
27	9.31	43.16	113.18	119.21	9.30	41.59	113.47	117.93
28	7.08	22.88	111.06	170.68	7.04	22.50	111.28	168.91
29	6.22	21.23	105.31	200.04	6.21	21.08	105.54	198.02
30	5.55	0.42	95.67	16.57	5.50	0.44	97.47	17.52
31	8.08	3.45	95.60	16.49	8.05	3.57	97.40	17.44
32	8.71	4.67	95.69	16.47	8.66	4.78	97.50	17.42
33	9.79	5.16	95.79	16.49	9.73	5.22	97.61	17.42
34	11.45	11.79	96.12	16.63	11.45	12.01	97.92	17.58
35	5.48	1.22	98.93	18.26	5.43	1.28	100.57	19.30
36	7.94	8.73	98.83	18.19	7.90	9.10	100.49	19.22
37	8.77	12.16	98.21	17.72	8.71	12.42	99.91	18.73
38	9.95	13.92	97.96	17.56	9.89	14.11	99.68	18.56
39	8.81	19.04	106.98	24.78	8.74	19.43	108.16	26.23
40	10.09	22.44	106.07	23.78	10.04	22.74	107.32	25.17
41	11.77	25.92	102.62	20.73	11.78	26.41	104.08	21.93
42	7.08	6.34	111.27	32.86	7.07	6.71	112.08	34.77
43	8.83	25.65	113.89	39.75	8.76	26.17	114.50	42.02
44	10.20	31.04	113.20	37.41	10.15	31.42	113.90	39.60
45	7.45	17.55	115.35	80.79	7.42	18.51	115.68	85.04

46	8.89	38.07	114.37	82.04	8.82	38.76	115.04	87.10
47	7.26	26.28	115.15	180.60	7.23	27.90	115.49	189.09
48	6.39	0.21	48.47	4.91	6.34	0.22	55.48	5.61
49	7.57	0.86	48.45	4.90	7.70	0.96	55.40	5.61
50	10.60	2.13	48.46	4.90	10.40	2.16	55.44	5.61
51	11.79	3.49	48.47	4.89	11.73	3.51	55.46	5.61
52	12.71	8.44	48.48	4.89	12.71	8.65	55.51	5.61
53	6.40	0.58	48.63	4.93	6.35	0.61	56.37	5.74
54	7.53	2.42	48.62	4.93	7.64	2.62	56.36	5.74
55	10.12	5.49	48.67	4.93	10.04	5.69	56.49	5.76
56	11.55	8.77	48.60	4.91	11.50	9.00	56.11	5.69
57	9.99	8.78	50.00	5.20	9.94	9.13	62.52	6.70
58	11.56	14.19	49.48	5.09	11.52	14.58	59.97	6.29
59	12.92	18.71	48.88	4.98	12.91	19.18	57.33	5.88
60	6.74	2.29	50.37	5.33	6.73	2.38	64.64	7.13
61	9.95	12.03	53.25	6.02	9.91	12.51	73.73	9.14
62	11.61	19.85	51.88	5.63	11.58	20.36	68.71	7.93
63	7.02	5.80	54.03	9.04	7.05	6.07	77.46	14.63
64	9.87	16.57	54.29	13.32	9.83	17.33	77.15	21.11
65	4.88	0.27	89.26	13.32	4.92	0.25	88.87	11.98
66	8.14	2.90	89.17	13.25	8.16	2.69	88.78	11.93
67	8.83	3.99	89.21	13.24	8.92	3.79	88.81	11.91
68	9.87	4.32	89.28	13.24	10.04	4.20	88.88	11.91
69	11.41	8.79	89.85	13.46	11.55	8.61	89.47	12.11
70	4.68	0.74	94.64	15.67	4.71	0.68	94.33	14.09
71	8.05	7.14	94.56	15.57	8.07	6.62	94.24	14.00
72	8.65	9.51	93.37	14.93	8.74	8.97	93.04	13.43
73	9.77	10.35	92.83	14.65	9.94	10.01	92.48	13.18
74	8.64	14.51	105.50	23.43	8.72	13.66	105.28	21.05
75	9.93	16.47	104.26	22.01	10.09	15.91	104.02	19.76
76	11.91	19.60	99.76	18.43	12.05	19.18	99.48	16.57
77	7.38	4.56	110.59	33.19	7.40	4.16	110.44	29.78
78	8.65	19.26	113.25	40.71	8.73	18.14	113.13	36.50
79	10.10	22.77	112.47	37.33	10.26	22.02	112.34	33.48
80	11.93	27.60	109.39	29.66	12.07	27.01	109.22	26.62
81	7.73	12.96	115.20	95.77	7.76	11.92	115.10	85.17
82	7.63	16.89	115.03	271.34	7.67	15.52	114.97	238.57
83	5.90	0.41	96.84	28.48	5.90	0.41	97.66	28.10
84	8.27	2.97	96.80	28.34	8.26	2.89	97.62	27.96
85	8.93	4.15	96.91	28.33	8.94	4.03	97.74	27.93
86	9.60	4.29	97.01	28.33	9.66	4.20	97.85	27.92
87	11.23	9.10	97.12	28.45	11.38	8.99	97.95	28.05
88	5.87	1.18	98.77	30.50	5.87	1.18	99.55	30.08
89	8.15	6.91	98.86	30.45	8.12	6.70	99.65	30.04
90	8.90	10.34	99.06	30.48	8.89	9.92	99.85	30.07
91	9.65	11.09	98.30	29.60	9.70	10.74	99.11	29.20
92	8.94	16.20	106.92	42.06	8.92	15.53	107.50	41.53

93	9.82	18.08	104.32	36.14	9.87	17.52	104.66	36.35
94	11.66	20.75	100.28	31.84	11.81	20.55	101.05	31.42
95	6.78	4.68	108.73	47.87	6.75	4.62	109.23	47.26
96	8.97	21.78	113.43	68.10	8.95	20.87	113.76	67.24
97	9.96	25.20	110.83	54.47	10.02	24.42	111.27	53.78
98	11.64	29.26	106.35	41.48	11.79	28.94	106.94	40.95
99	7.34	11.53	113.91	128.02	7.30	11.25	114.16	126.34
100	7.04	15.22	112.11	361.73	7.00	14.92	112.34	356.67
101	6.25	10.39	106.88	652.48	6.25	10.32	107.15	642.56
102	6.08	9.27	98.86	878.05	6.08	9.23	99.15	864.71
103	4.94	0.30	94.75	18.69	4.88	0.31	96.51	19.93
104	8.14	3.18	94.67	18.59	8.10	3.27	96.44	19.84
105	8.74	4.28	94.75	18.58	8.70	4.36	96.53	19.82
106	9.64	4.47	94.85	18.58	9.59	4.52	96.63	19.82
107	11.15	8.94	95.16	18.80	11.17	9.14	96.94	20.04
108	4.73	0.82	98.01	20.90	4.68	0.87	99.62	22.32
109	8.06	7.80	97.92	20.78	8.02	8.07	99.54	22.18
110	8.59	10.24	97.28	20.20	8.53	10.47	98.95	21.56
111	9.56	10.80	97.02	19.96	9.52	10.98	98.71	21.30
112	8.58	15.67	106.26	28.83	8.52	16.01	107.44	30.75
113	9.71	17.18	105.35	27.47	9.67	17.48	106.60	29.39
114	11.66	19.91	101.81	23.77	11.69	20.42	103.26	25.39
115	7.38	4.97	110.74	38.74	7.34	5.28	111.57	41.40
116	8.59	20.80	113.46	47.13	8.53	21.25	114.14	50.59
117	7.73	14.03	115.37	110.35	7.69	14.72	115.76	119.25
118	8.67	30.23	114.49	116.58	8.62	30.73	115.08	126.04
119	7.64	18.11	114.92	316.57	7.58	19.07	115.28	345.48
120	6.98	10.76	109.72	522.64	6.95	11.44	110.24	573.61
121	8.85	48.29	106.59	396.10	8.81	49.12	107.57	434.08
122	6.22	7.94	104.56	750.50	6.20	8.57	105.21	824.56
123	6.39	0.21	47.95	5.74	6.36	0.22	53.25	6.45
124	7.65	0.90	47.94	5.74	7.78	0.98	53.19	6.44
125	10.58	2.13	47.94	5.72	10.49	2.22	53.20	6.44
126	11.80	3.39	47.94	5.72	11.71	3.40	53.21	6.44
127	12.77	8.00	47.95	5.72	12.74	7.85	53.25	6.44
128	6.40	0.60	48.10	5.77	6.36	0.60	54.01	6.59
129	7.51	2.44	48.10	5.77	7.58	2.57	54.00	6.59
130	10.07	5.16	48.12	5.77	10.01	5.20	54.09	6.59
131	11.59	8.21	48.06	5.74	11.55	8.08	53.75	6.53
132	9.89	8.09	49.30	6.04	9.83	8.05	59.29	7.55
133	11.60	13.19	48.82	5.92	11.57	12.95	57.06	7.13
134	6.73	2.33	49.69	6.17	6.73	2.37	61.32	8.01
135	9.82	11.03	52.40	6.85	9.76	10.91	70.04	10.07
136	6.99	5.81	53.79	10.41	7.01	5.88	74.56	16.49
137	9.75	15.13	54.10	15.60	9.71	14.99	74.10	24.35
138	6.89	9.38	53.90	24.32	6.89	9.31	74.16	39.39

Appendix B: Data of mooring line tensions of designed mooring system B

	Line1				Line2			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.02	0.26	78.69	14.26	5.01	0.29	79.06	15.83
2	7.97	2.42	78.60	14.20	7.95	2.62	78.97	15.76
3	8.93	3.42	78.61	14.18	8.82	3.60	78.98	15.73
4	10.14	3.91	78.64	14.18	9.96	4.00	79.02	15.72
5	11.93	8.83	79.18	14.38	11.81	9.03	79.56	15.96
6	4.83	0.73	83.79	16.53	4.83	0.81	84.14	18.37
7	7.93	6.13	83.69	16.43	7.91	6.65	84.04	18.25
8	8.73	8.38	82.49	15.81	8.63	8.86	82.86	17.56
9	10.10	9.77	81.95	15.54	9.93	10.08	82.32	17.27
10	8.71	12.98	94.81	24.16	8.62	13.79	95.09	26.90
11	10.27	15.86	93.45	22.76	10.11	16.40	93.74	25.33
12	7.29	4.22	100.58	33.92	7.26	4.64	100.78	37.81
13	7.66	11.62	106.16	97.11	7.63	12.69	106.26	108.90
14	8.78	25.27	104.80	98.91	8.71	26.89	104.95	111.01
15	7.57	15.39	106.51	267.11	7.54	16.84	106.58	303.24
16	6.31	0.17	51.42	7.24	6.37	0.16	47.21	6.72
17	7.70	0.88	51.39	7.24	7.63	0.80	47.20	6.71
18	10.63	2.16	51.41	7.24	10.78	2.17	47.20	6.71
19	11.78	3.48	51.42	7.24	11.79	3.47	47.21	6.71
20	6.33	0.48	52.09	7.39	6.39	0.47	47.33	6.77
21	7.62	2.40	52.11	7.39	7.56	2.26	47.33	6.75
22	10.20	5.43	52.17	7.39	10.28	5.35	47.35	6.77
23	10.08	8.62	56.64	8.40	10.13	8.43	48.31	7.08
24	6.85	2.14	58.48	8.88	6.85	2.08	48.66	7.24
25	10.05	11.80	65.73	11.07	10.08	11.51	50.70	8.05
26	7.08	5.54	69.48	17.68	7.06	5.38	51.61	12.07
27	9.95	16.26	68.93	25.21	9.99	15.75	51.55	17.52
28	6.92	8.96	69.17	39.05	6.93	8.66	51.18	26.76
29	6.72	6.85	61.52	58.49	6.77	6.45	48.38	45.18
30	5.56	0.48	90.13	19.29	5.61	0.46	88.49	18.27
31	7.83	3.29	90.10	19.22	7.86	3.16	88.44	18.19
32	8.50	4.19	90.17	19.20	8.57	4.08	88.51	18.17
33	9.86	4.78	90.26	19.20	9.94	4.72	88.59	18.19
34	11.75	11.75	90.59	19.40	11.75	11.51	88.94	18.38
35	5.49	1.38	93.29	21.49	5.53	1.32	91.79	20.35
36	7.75	8.60	93.24	21.41	7.78	8.21	91.73	20.27
37	8.57	11.36	92.64	20.82	8.64	11.07	91.08	19.71
38	9.94	13.25	92.39	20.59	10.00	13.05	90.81	19.51
39	8.62	18.15	100.63	29.75	8.69	17.73	99.55	28.15
40	10.07	21.70	99.86	28.49	10.13	21.38	98.71	26.93
41	12.00	26.22	96.77	24.67	11.99	25.67	95.44	23.34
42	7.02	6.89	104.17	39.89	7.03	6.51	103.41	37.72
43	8.66	24.73	106.34	48.42	8.74	24.18	105.73	45.78
44	10.19	30.26	105.83	45.48	10.24	29.85	105.17	42.99

45	7.37	18.30	107.81	101.18	7.39	17.33	107.46	96.15
46	8.75	36.83	107.40	101.61	8.82	36.13	106.88	96.75
47	7.21	27.44	108.01	219.85	7.23	25.86	107.65	209.13
48	5.86	0.43	91.25	25.88	5.87	0.43	90.51	26.23
49	8.23	2.90	91.24	25.78	8.24	2.98	90.49	26.13
50	9.01	4.13	91.33	25.76	9.00	4.26	90.58	26.12
51	10.23	4.92	91.42	25.76	10.18	5.03	90.67	26.12
52	12.07	12.47	91.53	25.85	11.97	12.60	90.78	26.19
53	5.84	1.26	93.03	27.42	5.84	1.27	92.33	27.78
54	8.16	6.77	93.16	27.44	8.19	6.98	92.45	27.80
55	9.25	11.09	93.34	27.56	9.25	11.48	92.64	27.92
56	10.45	13.87	92.62	26.81	10.39	14.20	91.89	27.17
57	9.32	17.77	100.40	37.85	9.32	18.39	99.90	38.34
58	10.58	22.86	97.85	33.33	10.53	23.41	97.26	33.75
59	12.29	27.96	94.48	28.83	12.19	28.23	93.80	29.22
60	6.67	4.78	101.96	42.40	6.70	4.84	101.53	42.95
61	9.36	24.38	106.11	60.09	9.37	25.25	105.83	60.83
62	10.67	32.08	103.78	48.88	10.62	32.85	103.41	49.49
63	7.31	12.71	106.49	97.08	7.35	12.98	106.28	98.27
64	9.30	38.20	107.49	132.93	9.30	39.70	107.25	134.63
65	5.63	0.40	82.94	12.16	5.60	0.42	83.27	13.39
66	7.80	2.57	82.87	12.11	7.81	2.81	83.20	13.32
67	8.73	3.44	82.89	12.09	8.63	3.67	83.22	13.31
68	10.35	4.29	82.95	12.09	10.17	4.44	83.28	13.32
69	12.08	10.75	83.55	12.28	11.98	11.08	83.88	13.54
70	5.57	1.14	88.39	14.29	5.53	1.22	88.70	15.75
71	7.72	6.79	88.30	14.23	7.72	7.40	88.61	15.69
72	8.74	9.38	87.10	13.65	8.66	10.00	87.42	15.02
73	10.31	11.74	86.56	13.41	10.17	12.21	86.88	14.76
74	8.78	15.09	98.62	21.49	8.71	16.08	98.86	23.67
75	10.42	19.28	97.47	20.25	10.29	20.04	97.72	22.33
76	12.30	24.02	93.28	16.98	12.20	24.75	93.56	18.71
77	6.99	5.53	103.07	30.13	7.00	6.01	103.23	33.18
78	8.82	20.66	105.32	36.76	8.75	21.98	105.46	40.48
79	10.52	26.97	104.67	34.03	10.40	28.01	104.82	37.50
80	12.22	33.53	102.03	27.30	12.13	34.53	102.22	30.09
81	7.34	14.64	107.00	79.94	7.35	15.91	107.11	87.86
82	7.19	21.98	107.13	177.48	7.19	23.86	107.24	193.62
83	6.31	0.17	52.53	6.61	6.36	0.17	47.38	5.90
84	7.68	0.82	52.50	6.61	7.60	0.77	47.38	5.90
85	10.75	2.19	52.50	6.59	10.81	2.14	47.38	5.90
86	11.71	3.35	52.50	6.59	11.78	3.36	47.38	5.89
87	12.86	8.02	52.57	6.61	12.88	8.14	47.40	5.90
88	6.33	0.50	53.40	6.78	6.38	0.48	47.58	5.95
89	7.51	2.26	53.43	6.78	7.48	2.19	47.58	5.95
90	10.22	5.10	53.50	6.81	10.27	5.08	47.61	5.95
91	11.65	8.09	53.13	6.72	11.69	8.19	47.53	5.93

92	10.01	7.83	59.09	8.01	10.06	7.87	48.99	6.36
93	11.71	13.03	56.79	7.49	11.73	13.22	48.46	6.19
94	13.15	17.99	54.32	6.95	13.15	18.20	47.84	6.01
95	6.77	2.16	61.25	8.59	6.80	2.10	49.51	6.57
96	9.93	10.59	69.37	11.08	9.98	10.67	52.29	7.54
97	11.78	18.28	64.77	9.56	11.79	18.52	50.87	6.97
98	13.10	25.21	59.28	8.03	13.10	25.47	49.22	6.38
99	6.99	5.45	73.41	18.31	7.01	5.37	53.82	11.76
100	6.89	8.63	74.27	43.69	6.90	8.62	54.45	27.35
101	6.73	6.27	67.24	71.42	6.76	6.30	51.56	47.54
102	6.65	5.46	59.78	97.49	6.69	5.53	48.84	70.09
103	5.03	0.35	89.29	21.33	5.07	0.33	87.64	20.05
104	7.91	2.96	89.24	21.24	7.94	2.85	87.59	19.96
105	8.64	3.90	89.31	21.21	8.69	3.80	87.65	19.95
106	9.65	4.14	89.39	21.21	9.72	4.08	87.72	19.95
107	11.62	9.40	89.73	21.49	11.59	9.12	88.08	20.19
108	4.85	0.97	92.53	24.11	4.88	0.90	91.02	22.65
109	7.87	7.56	92.48	23.98	7.91	7.24	90.96	22.50
110	8.48	9.76	91.84	23.25	8.54	9.50	90.28	21.82
111	9.66	10.65	91.58	22.96	9.70	10.42	90.00	21.55
112	8.48	15.24	100.11	33.93	8.54	14.84	99.02	31.79
113	9.84	17.37	99.32	32.27	9.88	16.97	98.16	30.22
114	12.04	21.46	96.12	27.71	12.02	20.81	94.78	25.99
115	7.22	5.38	103.81	46.47	7.26	5.03	103.06	43.45
116	8.51	20.50	106.06	56.85	8.57	19.95	105.46	53.11
117	7.59	14.53	107.62	132.99	7.64	13.77	107.25	123.59
118	8.60	29.77	107.18	139.02	8.65	29.14	106.63	129.11
119	7.50	19.27	107.77	377.84	7.55	18.17	107.44	348.01
120	6.91	11.91	103.90	612.91	6.93	11.12	103.43	561.80
121	8.81	49.32	101.45	461.25	8.85	48.21	100.60	422.80
122	6.25	9.25	99.96	849.07	6.25	8.48	99.24	774.47
123	5.90	0.40	85.21	31.14	5.91	0.40	84.56	31.64
124	7.95	2.14	85.16	31.00	7.97	2.20	84.51	31.51
125	9.02	3.12	85.22	30.97	8.99	3.21	84.57	31.48
126	9.99	3.49	85.28	30.95	9.92	3.56	84.63	31.47
127	12.24	9.04	85.40	31.10	12.09	9.07	84.75	31.62
128	5.88	1.17	87.22	33.35	5.88	1.17	86.59	33.90
129	7.82	5.39	87.33	33.34	7.86	5.56	86.70	33.89
130	8.86	8.33	87.50	33.38	8.87	8.69	86.87	33.91
131	9.99	9.71	86.64	32.39	9.91	9.98	85.99	32.91
132	8.89	13.66	96.19	46.41	8.91	14.27	95.67	47.10
133	10.15	16.50	92.95	40.58	10.07	16.95	92.38	41.17
134	6.57	4.36	98.38	52.90	6.59	4.41	97.92	53.67
135	8.93	18.83	103.94	75.52	8.95	19.68	103.62	76.60
136	7.05	10.36	105.13	140.36	7.09	10.57	104.88	142.40
137	9.04	29.08	105.90	207.38	9.05	30.48	105.63	210.38
138	6.83	14.79	104.44	389.00	6.86	15.00	104.21	394.96

	Line3				Line4			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.01	0.32	79.38	17.29	4.99	0.34	80.39	18.45
2	7.92	2.79	79.29	17.20	7.90	2.92	80.30	18.37
3	8.72	3.75	79.29	17.19	8.66	3.87	80.31	18.33
4	9.81	4.08	79.33	17.17	9.71	4.16	80.36	18.33
5	11.72	9.24	79.87	17.44	11.70	9.50	80.89	18.61
6	4.83	0.89	84.44	20.08	4.82	0.96	85.42	21.47
7	7.89	7.11	84.35	19.97	7.86	7.49	85.32	21.33
8	8.55	9.33	83.16	19.20	8.49	9.67	84.16	20.50
9	9.79	10.39	82.63	18.87	9.72	10.67	83.63	20.15
10	8.55	14.54	95.32	29.45	8.49	15.09	96.07	31.57
11	9.97	16.93	93.99	27.71	9.90	17.40	94.78	29.68
12	7.24	5.03	100.94	41.43	7.21	5.38	101.47	44.50
13	7.61	13.67	106.33	120.01	7.58	14.50	106.59	129.59
14	8.65	28.39	105.06	122.43	8.60	29.39	105.46	132.24
15	7.51	18.17	106.63	337.54	7.48	19.33	106.86	367.61
16	6.36	0.17	47.05	6.83	6.29	0.17	50.90	7.48
17	7.53	0.73	47.05	6.83	7.48	0.71	50.87	7.47
18	10.89	2.19	47.05	6.83	10.92	2.22	50.87	7.45
19	11.78	3.46	47.05	6.83	11.75	3.46	50.88	7.45
20	6.38	0.47	47.12	6.86	6.31	0.50	51.40	7.61
21	7.47	2.14	47.11	6.86	7.40	2.10	51.40	7.60
22	10.35	5.28	47.11	6.86	10.37	5.26	51.42	7.59
23	10.16	8.25	47.52	7.10	10.15	8.14	54.66	8.44
24	6.81	2.07	47.78	7.26	6.74	2.12	56.38	8.94
25	10.09	11.23	48.58	7.83	10.07	11.04	61.69	10.76
26	7.01	5.30	49.62	11.89	6.95	5.33	66.02	17.67
27	10.02	15.26	49.41	17.26	10.01	14.93	65.19	25.17
28	6.90	8.52	50.25	27.42	6.87	8.54	67.62	42.13
29	6.77	6.26	49.08	48.50	6.72	6.31	63.28	70.65
30	5.65	0.43	87.12	17.04	5.69	0.41	86.44	15.53
31	7.87	2.98	87.07	16.98	7.88	2.74	86.38	15.47
32	8.65	3.92	87.12	16.96	8.74	3.70	86.44	15.46
33	10.06	4.63	87.20	16.96	10.22	4.49	86.52	15.46
34	11.78	11.25	87.56	17.14	11.88	10.93	86.87	15.63
35	5.58	1.24	90.52	18.97	5.62	1.16	89.88	17.30
36	7.80	7.74	90.45	18.90	7.80	7.14	89.81	17.23
37	8.72	10.67	89.77	18.37	8.79	10.05	89.11	16.75
38	10.09	12.76	89.48	18.19	10.22	12.30	88.82	16.57
39	8.77	17.10	98.61	26.22	8.85	16.13	98.12	23.89
40	10.21	20.92	97.72	25.09	10.33	20.17	97.21	22.86
41	12.02	25.09	94.30	21.75	12.10	24.38	93.72	19.82
42	7.03	6.07	102.74	35.13	7.02	5.60	102.39	32.01
43	8.82	23.34	105.20	42.62	8.89	22.06	104.91	38.84
44	10.32	29.23	104.58	40.01	10.44	28.21	104.27	36.44
45	7.40	16.21	107.12	89.80	7.40	14.95	106.92	82.03

46	8.88	34.93	106.43	90.74	8.95	32.91	106.15	83.11
47	7.25	24.14	107.28	195.68	7.25	22.27	107.00	179.27
48	5.87	0.43	89.99	26.36	5.87	0.43	90.28	26.08
49	8.25	3.02	89.97	26.24	8.24	2.97	90.25	25.97
50	9.01	4.33	90.06	26.24	9.01	4.25	90.34	25.95
51	10.15	5.09	90.14	26.25	10.18	5.02	90.42	25.96
52	11.92	12.66	90.25	26.32	11.97	12.57	90.54	26.05
53	5.84	1.26	91.84	27.91	5.84	1.26	92.10	27.62
54	8.20	7.08	91.96	27.93	8.19	6.96	92.23	27.64
55	9.25	11.69	92.14	28.04	9.25	11.46	92.40	27.76
56	10.36	14.41	91.38	27.28	10.39	14.19	91.65	27.01
57	9.33	18.75	99.54	38.50	9.33	18.38	99.72	38.10
58	10.49	23.73	96.84	33.89	10.52	23.39	97.05	33.55
59	12.13	28.37	93.32	29.33	12.18	28.17	93.57	29.04
60	6.72	4.86	101.22	43.12	6.70	4.82	101.37	42.71
61	9.37	25.75	105.61	61.05	9.37	25.23	105.70	60.47
62	10.58	33.30	103.14	49.65	10.62	32.82	103.26	49.16
63	7.38	13.12	106.12	98.69	7.36	12.93	106.19	97.85
64	9.30	40.56	107.07	135.14	9.30	39.66	107.14	133.81
65	5.57	0.45	83.55	14.51	5.53	0.48	84.57	15.39
66	7.81	3.03	83.48	14.44	7.79	3.19	84.50	15.33
67	8.55	3.89	83.51	14.44	8.49	4.04	84.53	15.31
68	10.02	4.58	83.57	14.42	9.92	4.67	84.60	15.31
69	11.89	11.39	84.17	14.68	11.86	11.67	85.19	15.57
70	5.50	1.30	88.97	17.08	5.46	1.37	89.91	18.12
71	7.72	7.96	88.88	16.99	7.71	8.40	89.82	18.04
72	8.60	10.59	87.70	16.30	8.54	10.99	88.67	17.30
73	10.06	12.65	87.16	16.01	9.98	12.96	88.14	16.99
74	8.65	16.98	99.05	25.67	8.58	17.59	99.71	27.29
75	10.18	20.76	97.93	24.21	10.11	21.25	98.62	25.74
76	12.12	25.45	93.80	20.28	12.11	26.09	94.62	21.57
77	7.01	6.45	103.37	35.98	7.00	6.85	103.81	38.26
78	8.69	23.18	105.58	43.89	8.62	24.01	105.93	46.69
79	10.29	28.99	104.94	40.68	10.22	29.66	105.33	43.27
80	12.05	35.49	102.37	32.65	12.03	36.35	102.87	34.72
81	7.35	17.08	107.20	95.02	7.34	18.09	107.43	100.84
82	7.20	25.58	107.39	208.81	7.18	27.16	107.67	221.02
83	6.35	0.17	47.22	5.90	6.29	0.18	52.06	6.51
84	7.50	0.74	47.22	5.90	7.45	0.74	52.03	6.51
85	10.85	2.10	47.22	5.90	10.82	2.07	52.04	6.51
86	11.84	3.38	47.22	5.90	11.87	3.40	52.06	6.51
87	12.91	8.32	47.22	5.90	12.95	8.57	52.08	6.51
88	6.37	0.48	47.29	5.95	6.31	0.50	52.64	6.64
89	7.44	2.14	47.29	5.93	7.41	2.17	52.65	6.64
90	10.30	5.08	47.29	5.93	10.29	5.15	52.68	6.64
91	11.73	8.36	47.26	5.93	11.75	8.57	52.41	6.58
92	10.11	7.95	47.75	6.19	10.11	8.12	56.37	7.50

93	11.76	13.50	47.51	6.08	11.77	13.88	54.59	7.08
94	13.16	18.61	47.32	5.95	13.17	19.15	53.02	6.72
95	6.80	2.09	48.03	6.37	6.77	2.14	58.19	7.98
96	10.03	10.82	48.87	6.98	10.05	11.09	63.72	9.78
97	11.81	18.91	48.20	6.56	11.82	19.43	59.77	8.51
98	13.10	26.01	47.67	6.17	13.11	26.75	55.91	7.40
99	7.00	5.36	49.64	10.64	6.98	5.46	67.35	15.91
100	6.88	8.71	49.55	23.98	6.85	8.98	67.27	35.48
101	6.74	6.52	47.93	41.87	6.68	6.96	61.09	54.29
102	6.67	5.90	46.38	61.31	6.60	6.55	54.91	68.48
103	5.10	0.30	86.26	18.54	5.12	0.27	85.55	16.74
104	7.98	2.71	86.21	18.45	8.00	2.53	85.49	16.67
105	8.76	3.68	86.26	18.45	8.87	3.52	85.54	16.65
106	9.83	4.02	86.33	18.44	10.00	3.93	85.61	16.64
107	11.63	8.90	86.69	18.66	11.73	8.70	85.98	16.85
108	4.91	0.83	89.75	20.91	4.92	0.75	89.09	18.85
109	7.95	6.85	89.68	20.79	7.98	6.35	89.02	18.73
110	8.61	9.15	88.96	20.15	8.70	8.67	88.28	18.19
111	9.79	10.17	88.66	19.90	9.95	9.86	87.98	17.95
112	8.61	14.28	98.08	29.28	8.69	13.49	97.59	26.37
113	9.96	16.55	97.17	27.86	10.12	16.02	96.66	25.10
114	12.04	20.25	93.63	23.97	12.16	19.80	93.04	21.61
115	7.29	4.67	102.40	39.96	7.32	4.26	102.06	35.93
116	8.64	19.22	104.93	48.80	8.72	18.14	104.66	43.85
117	7.68	12.88	106.93	112.96	7.71	11.85	106.77	100.93
118	8.71	28.17	106.14	117.92	8.78	26.59	105.90	105.22
119	7.60	16.95	107.16	314.91	7.64	15.54	107.04	278.12
120	6.96	10.28	103.04	504.16	6.98	9.39	102.91	442.18
121	8.90	46.63	99.90	380.33	8.98	44.17	99.67	333.94
122	6.26	7.72	98.69	696.20	6.26	6.99	98.56	611.32
123	5.91	0.40	84.13	31.81	5.91	0.40	84.49	31.45
124	7.98	2.23	84.07	31.66	7.97	2.20	84.43	31.30
125	8.99	3.26	84.13	31.65	9.00	3.20	84.49	31.29
126	9.89	3.60	84.19	31.65	9.93	3.56	84.55	31.28
127	11.98	9.09	84.31	31.80	12.06	9.05	84.67	31.41
128	5.88	1.17	86.16	34.09	5.88	1.17	86.50	33.69
129	7.89	5.67	86.27	34.06	7.87	5.56	86.61	33.67
130	8.88	8.92	86.44	34.09	8.87	8.71	86.78	33.69
131	9.87	10.16	85.56	33.09	9.91	9.99	85.91	32.71
132	8.92	14.64	95.31	47.31	8.91	14.29	95.56	46.75
133	10.02	17.24	91.99	41.36	10.07	16.96	92.27	40.89
134	6.60	4.43	97.60	53.89	6.59	4.39	97.82	53.27
135	8.97	20.18	103.39	76.85	8.96	19.71	103.63	75.50
136	7.11	10.68	104.71	142.87	7.10	10.55	104.80	141.19
137	9.06	31.30	105.43	211.08	9.06	30.54	105.55	208.42
138	6.89	15.12	104.06	396.28	6.87	14.97	104.17	391.19

	Line5				Line6			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	4.99	0.34	80.36	18.45	5.01	0.32	79.35	17.29
2	7.90	2.93	80.28	18.37	7.93	2.79	79.27	17.20
3	8.66	3.87	80.29	18.33	8.72	3.76	79.27	17.19
4	9.71	4.16	80.33	18.33	9.81	4.09	79.31	17.17
5	11.70	9.50	80.86	18.61	11.72	9.24	79.85	17.43
6	4.82	0.96	85.39	21.47	4.83	0.89	84.42	20.08
7	7.86	7.49	85.29	21.34	7.89	7.12	84.31	19.97
8	8.49	9.68	84.13	20.50	8.55	9.34	83.13	19.20
9	9.72	10.67	83.61	20.14	9.79	10.40	82.60	18.87
10	8.49	15.10	96.04	31.57	8.55	14.54	95.29	29.45
11	9.90	17.40	94.75	29.68	9.97	16.93	93.96	27.71
12	7.21	5.38	101.43	44.49	7.24	5.03	100.91	41.43
13	7.58	14.51	106.54	129.58	7.61	13.67	106.30	120.01
14	8.60	29.40	105.42	132.26	8.65	28.40	105.03	122.42
15	7.48	19.34	106.79	367.66	7.51	18.17	106.58	337.57
16	5.91	0.40	84.33	31.42	5.91	0.40	84.05	31.80
17	7.97	2.20	84.27	31.28	7.98	2.24	83.99	31.65
18	9.00	3.21	84.33	31.25	8.99	3.26	84.05	31.64
19	9.93	3.56	84.39	31.24	9.89	3.60	84.11	31.63
20	5.88	1.17	86.36	33.66	5.88	1.17	86.09	34.07
21	7.87	5.57	86.46	33.64	7.89	5.68	86.19	34.05
22	8.87	8.71	86.63	33.67	8.88	8.92	86.36	34.07
23	8.91	14.30	95.46	46.72	8.92	14.64	95.26	47.27
24	6.59	4.40	97.74	53.23	6.60	4.43	97.56	53.87
25	8.96	19.71	103.61	75.29	8.97	20.18	103.37	76.82
26	7.10	10.56	104.77	141.07	7.12	10.69	104.69	142.84
27	9.06	30.54	105.50	208.29	9.06	31.31	105.41	210.99
28	6.87	14.97	104.12	390.82	6.89	15.12	104.03	396.12
29	6.22	11.26	99.78	681.36	6.22	11.31	99.62	690.54
30	5.12	0.27	85.54	16.74	5.10	0.30	86.25	18.54
31	8.00	2.53	85.48	16.67	7.98	2.71	86.20	18.45
32	8.87	3.52	85.53	16.64	8.76	3.68	86.25	18.45
33	10.00	3.93	85.59	16.64	9.83	4.02	86.32	18.44
34	11.73	8.70	85.96	16.85	11.62	8.89	86.68	18.66
35	4.92	0.75	89.07	18.85	4.90	0.83	89.74	20.91
36	7.98	6.35	89.00	18.76	7.95	6.85	89.67	20.79
37	8.70	8.66	88.27	18.19	8.61	9.15	88.95	20.18
38	9.95	9.86	87.96	17.97	9.80	10.17	88.65	19.90
39	8.69	13.48	97.57	26.37	8.61	14.28	98.06	29.27
40	10.12	16.01	96.63	25.10	9.96	16.54	97.15	27.86
41	12.16	19.79	93.03	21.61	12.04	20.25	93.63	23.99
42	7.32	4.26	102.02	35.92	7.29	4.67	102.38	39.96
43	8.72	18.14	104.63	43.85	8.64	19.21	104.91	48.82
44	10.28	22.38	103.96	40.75	10.13	23.11	104.27	45.33
45	7.71	11.85	106.73	100.95	7.68	12.88	106.91	112.98

46	8.78	26.57	105.87	105.25	8.71	28.15	106.13	117.91
47	7.64	15.54	107.00	278.11	7.60	16.95	107.14	314.91
48	6.29	0.18	51.89	6.51	6.35	0.17	47.09	5.93
49	7.44	0.74	51.86	6.51	7.49	0.73	47.09	5.92
50	10.82	2.07	51.87	6.51	10.86	2.10	47.09	5.92
51	11.87	3.40	51.89	6.51	11.84	3.37	47.09	5.92
52	12.95	8.57	51.92	6.51	12.91	8.32	47.10	5.92
53	6.31	0.50	52.47	6.63	6.38	0.48	47.16	5.98
54	7.41	2.17	52.48	6.63	7.43	2.14	47.16	5.97
55	10.29	5.14	52.50	6.63	10.30	5.08	47.15	5.95
56	11.75	8.56	52.23	6.58	11.73	8.35	47.12	5.95
57	10.11	8.12	56.10	7.48	10.11	7.95	47.54	6.21
58	11.77	13.87	54.38	7.07	11.76	13.50	47.34	6.08
59	13.17	19.13	52.84	6.71	13.16	18.60	47.18	5.98
60	6.77	2.14	57.98	7.98	6.80	2.10	47.83	6.39
61	10.05	11.08	63.25	9.72	10.03	10.81	48.47	6.98
62	11.82	19.42	59.43	8.47	11.81	18.90	47.90	6.56
63	6.98	5.47	66.90	15.86	7.00	5.37	49.14	10.66
64	9.96	14.99	65.38	21.90	9.94	14.63	48.46	15.12
65	5.53	0.48	84.58	15.39	5.57	0.45	83.56	14.51
66	7.79	3.19	84.51	15.33	7.81	3.03	83.49	14.44
67	8.49	4.04	84.54	15.31	8.55	3.89	83.51	14.44
68	9.92	4.67	84.59	15.31	10.02	4.58	83.57	14.44
69	11.86	11.67	85.20	15.57	11.89	11.39	84.18	14.68
70	5.46	1.37	89.91	18.15	5.50	1.30	88.98	17.08
71	7.71	8.40	89.82	18.06	7.72	7.96	88.88	17.00
72	8.54	10.99	88.68	17.30	8.60	10.59	87.71	16.30
73	9.98	12.96	88.14	16.99	10.06	12.65	87.16	16.02
74	8.58	17.61	99.69	27.30	8.65	16.98	99.05	25.67
75	10.11	21.25	98.62	25.75	10.18	20.76	97.93	24.21
76	12.10	26.09	94.62	21.57	12.13	25.45	93.80	20.30
77	7.00	6.85	103.79	38.27	7.01	6.46	103.37	35.98
78	8.62	24.01	105.92	46.70	8.68	23.19	105.58	43.89
79	10.22	29.66	105.31	43.30	10.29	28.99	104.93	40.68
80	12.03	36.34	102.85	34.75	12.05	35.49	102.36	32.65
81	7.34	18.10	107.40	100.89	7.35	17.09	107.19	95.05
82	7.18	27.18	107.65	221.14	7.20	25.60	107.40	208.90
83	5.87	0.43	90.45	26.11	5.87	0.43	90.09	26.37
84	8.25	2.97	90.43	26.00	8.26	3.03	90.07	26.25
85	9.01	4.25	90.52	26.00	9.01	4.34	90.16	26.26
86	10.18	5.02	90.61	26.00	10.15	5.09	90.25	26.26
87	11.96	12.56	90.71	26.07	11.91	12.66	90.35	26.33
88	5.84	1.26	92.26	27.64	5.84	1.26	91.93	27.92
89	8.19	6.96	92.38	27.67	8.20	7.08	92.05	27.94
90	9.25	11.47	92.56	27.78	9.25	11.69	92.23	28.06
91	10.39	14.19	91.83	27.03	10.37	14.39	91.48	27.31
92	9.33	18.38	99.81	38.11	9.33	18.76	99.60	38.50

93	10.52	23.39	97.17	33.55	10.50	23.72	96.91	33.89
94	12.18	28.16	93.72	29.06	12.13	28.37	93.41	29.34
95	6.70	4.82	101.44	42.69	6.72	4.86	101.27	43.12
96	9.37	25.23	105.74	60.44	9.37	25.76	105.64	61.04
97	10.61	32.82	103.32	49.15	10.58	33.30	103.18	49.65
98	12.09	39.41	99.30	37.76	12.04	39.71	99.09	38.15
99	7.36	12.94	106.20	97.73	7.38	13.13	106.13	98.62
100	7.03	20.83	105.89	203.30	7.05	21.08	105.83	205.13
101	6.21	19.20	102.39	232.63	6.21	19.38	102.27	234.73
102	6.00	22.08	97.16	195.21	6.00	22.22	96.92	196.55
103	5.69	0.41	86.44	15.54	5.65	0.43	87.12	17.05
104	7.88	2.74	86.39	15.47	7.87	2.98	87.06	16.98
105	8.74	3.69	86.45	15.46	8.65	3.92	87.13	16.96
106	10.22	4.49	86.52	15.46	10.06	4.63	87.20	16.96
107	11.88	10.93	86.88	15.63	11.78	11.25	87.55	17.14
108	5.62	1.16	89.89	17.30	5.58	1.24	90.52	18.99
109	7.80	7.13	89.82	17.23	7.80	7.74	90.46	18.90
110	8.80	10.04	89.12	16.75	8.72	10.67	89.77	18.38
111	10.22	12.30	88.83	16.57	10.09	12.76	89.48	18.19
112	8.85	16.13	98.13	23.88	8.77	17.09	98.61	26.22
113	10.33	20.17	97.23	22.86	10.21	20.92	97.73	25.09
114	12.10	24.38	93.73	19.81	12.02	25.08	94.30	21.75
115	7.02	5.60	102.41	32.01	7.03	6.07	102.75	35.13
116	8.89	22.06	104.93	38.83	8.82	23.34	105.21	42.62
117	7.40	14.96	106.95	82.02	7.40	16.21	107.13	89.78
118	8.95	32.90	106.17	83.08	8.88	34.90	106.44	90.71
119	7.25	22.26	107.04	179.19	7.25	24.13	107.30	195.62
120	6.79	16.67	103.41	221.79	6.78	18.28	103.62	236.83
121	9.02	59.36	100.47	164.84	8.95	63.15	100.86	175.20
122	6.45	16.11	99.17	218.95	6.43	17.92	99.59	234.92
123	6.30	0.17	50.46	7.47	6.36	0.16	46.93	6.88
124	7.49	0.71	50.42	7.47	7.53	0.73	46.93	6.88
125	10.92	2.22	50.43	7.44	10.89	2.19	46.93	6.87
126	11.76	3.45	50.43	7.44	11.79	3.46	46.93	6.87
127	12.84	8.31	50.46	7.45	12.84	8.39	46.93	6.85
128	6.31	0.49	50.97	7.59	6.38	0.47	46.99	6.91
129	7.40	2.09	50.97	7.59	7.47	2.13	46.99	6.91
130	10.37	5.25	50.97	7.58	10.35	5.27	46.98	6.90
131	11.68	8.44	50.73	7.52	11.68	8.54	46.96	6.88
132	10.16	8.12	54.16	8.41	10.17	8.23	47.33	7.12
133	11.73	13.65	52.59	8.02	11.72	13.82	47.14	7.02
134	6.74	2.12	55.92	8.93	6.81	2.07	47.60	7.31
135	10.08	11.03	61.10	10.70	10.10	11.21	48.25	7.85
136	6.95	5.30	65.46	17.64	7.01	5.27	49.20	11.91
137	10.02	14.88	63.98	24.81	10.02	15.20	48.61	17.20
138	6.87	8.46	66.75	41.94	6.90	8.44	49.48	27.52

	Line7				Line8			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.01	0.29	79.04	15.83	5.02	0.26	78.68	14.26
2	7.95	2.62	78.96	15.76	7.97	2.42	78.59	14.20
3	8.82	3.60	78.96	15.73	8.93	3.43	78.59	14.18
4	9.96	4.00	79.00	15.72	10.14	3.91	78.63	14.18
5	11.82	9.04	79.53	15.96	11.93	8.83	79.16	14.38
6	4.83	0.81	84.13	18.37	4.83	0.73	83.78	16.53
7	7.91	6.65	84.02	18.25	7.93	6.13	83.67	16.43
8	8.63	8.87	82.83	17.56	8.73	8.37	82.47	15.81
9	9.93	10.08	82.30	17.27	10.11	9.77	81.94	15.54
10	8.62	13.79	95.07	26.90	8.71	12.98	94.80	24.16
11	10.11	16.40	93.72	25.33	10.28	15.86	93.44	22.76
12	7.26	4.64	100.76	37.80	7.29	4.22	100.58	33.92
13	7.63	12.69	106.24	108.90	7.66	11.62	106.16	97.09
14	8.71	26.91	104.92	110.98	8.78	25.28	104.80	98.89
15	7.54	16.84	106.54	303.24	7.57	15.39	106.49	267.04
16	5.91	0.40	84.56	31.63	5.90	0.40	85.29	31.15
17	7.97	2.20	84.50	31.51	7.95	2.14	85.24	31.01
18	8.99	3.20	84.56	31.48	9.02	3.12	85.30	31.00
19	9.93	3.55	84.62	31.47	9.99	3.49	85.37	30.97
20	5.88	1.17	86.58	33.90	5.88	1.17	87.30	33.39
21	7.86	5.55	86.69	33.88	7.82	5.38	87.41	33.37
22	8.87	8.70	86.86	33.91	8.86	8.33	87.58	33.39
23	8.91	14.27	95.67	47.10	8.89	13.65	96.24	46.45
24	6.59	4.41	97.93	53.67	6.57	4.36	98.43	52.91
25	8.95	19.67	103.63	76.59	8.93	18.83	103.98	75.57
26	7.09	10.57	104.89	142.39	7.05	10.35	105.17	140.44
27	9.05	30.48	105.64	210.40	9.04	29.08	105.95	207.46
28	6.87	15.00	104.22	394.98	6.83	14.75	104.49	389.27
29	6.21	11.30	99.83	688.44	6.21	11.24	100.15	678.40
30	5.07	0.33	87.64	20.07	5.03	0.35	89.29	21.33
31	7.94	2.85	87.59	19.96	7.91	2.96	89.25	21.24
32	8.69	3.80	87.65	19.95	8.64	3.89	89.31	21.21
33	9.72	4.08	87.72	19.95	9.65	4.14	89.40	21.21
34	11.59	9.12	88.08	20.19	11.62	9.40	89.74	21.49
35	4.88	0.90	91.02	22.65	4.85	0.97	92.54	24.11
36	7.91	7.24	90.96	22.52	7.87	7.56	92.49	23.98
37	8.54	9.50	90.28	21.84	8.48	9.76	91.85	23.25
38	9.70	10.42	89.99	21.55	9.66	10.65	91.58	22.96
39	8.54	14.83	99.02	31.79	8.48	15.24	100.12	33.93
40	9.88	16.97	98.16	30.24	9.84	17.37	99.32	32.28
41	12.02	20.80	94.78	25.99	12.04	21.45	96.13	27.71
42	7.26	5.04	103.05	43.45	7.22	5.37	103.82	46.47
43	8.57	19.95	105.46	53.11	8.51	20.49	106.07	56.85
44	10.05	23.72	104.86	49.28	10.01	24.29	105.53	52.73
45	7.64	13.76	107.25	123.59	7.59	14.53	107.63	132.99

46	8.65	29.13	106.63	129.11	8.60	29.76	107.20	139.03
47	7.55	18.17	107.44	347.97	7.50	19.27	107.78	377.80
48	6.36	0.17	47.41	5.97	6.31	0.18	52.70	6.72
49	7.60	0.77	47.40	5.97	7.67	0.81	52.65	6.70
50	10.81	2.14	47.40	5.95	10.75	2.19	52.66	6.70
51	11.78	3.36	47.40	5.95	11.71	3.35	52.68	6.70
52	12.88	8.13	47.42	5.95	12.86	8.01	52.73	6.70
53	6.38	0.48	47.58	6.03	6.33	0.50	53.52	6.90
54	7.47	2.18	47.59	6.02	7.50	2.26	53.55	6.90
55	10.27	5.07	47.62	6.02	10.22	5.10	53.65	6.89
56	11.69	8.19	47.54	6.00	11.66	8.09	53.27	6.81
57	10.07	7.86	48.95	6.43	10.02	7.83	59.07	8.10
58	11.74	13.22	48.43	6.25	11.71	13.04	56.83	7.58
59	13.15	18.20	47.84	6.08	13.15	17.99	54.42	7.05
60	6.80	2.11	49.39	6.63	6.77	2.16	61.08	8.67
61	9.98	10.66	52.10	7.62	9.93	10.58	69.07	11.18
62	11.79	18.51	50.75	7.03	11.78	18.28	64.63	9.65
63	7.00	5.38	53.32	11.82	6.98	5.47	72.71	18.41
64	9.90	14.46	53.85	17.38	9.86	14.36	73.04	26.82
65	5.60	0.43	83.29	13.39	5.63	0.40	82.97	12.16
66	7.80	2.81	83.21	13.32	7.80	2.57	82.89	12.11
67	8.63	3.67	83.24	13.31	8.73	3.44	82.91	12.09
68	10.17	4.44	83.29	13.32	10.34	4.29	82.96	12.09
69	11.98	11.07	83.90	13.54	12.08	10.75	83.58	12.28
70	5.53	1.23	88.72	15.75	5.57	1.14	88.42	14.29
71	7.72	7.41	88.62	15.69	7.72	6.79	88.32	14.23
72	8.66	10.01	87.45	15.04	8.74	9.38	87.14	13.65
73	10.17	12.21	86.89	14.76	10.31	11.74	86.58	13.41
74	8.70	16.07	98.86	23.68	8.78	15.09	98.65	21.49
75	10.29	20.04	97.73	22.33	10.42	19.28	97.50	20.25
76	12.21	24.75	93.57	18.71	12.30	24.01	93.30	16.98
77	7.00	6.02	103.24	33.18	6.99	5.53	103.10	30.13
78	8.74	21.97	105.48	40.48	8.82	20.66	105.36	36.74
79	10.40	28.01	104.82	37.52	10.52	26.97	104.69	34.04
80	12.13	34.53	102.22	30.09	12.22	33.53	102.06	27.30
81	7.35	15.92	107.12	87.88	7.34	14.64	107.04	79.95
82	7.19	23.88	107.27	193.68	7.19	21.99	107.19	177.53
83	5.87	0.43	90.53	26.25	5.86	0.43	91.19	25.88
84	8.24	2.98	90.52	26.13	8.23	2.90	91.18	25.76
85	9.00	4.27	90.61	26.11	9.01	4.14	91.27	25.76
86	10.18	5.03	90.70	26.12	10.23	4.92	91.36	25.77
87	11.97	12.60	90.80	26.21	12.07	12.47	91.46	25.84
88	5.84	1.27	92.35	27.80	5.84	1.26	92.97	27.41
89	8.19	6.98	92.48	27.82	8.16	6.77	93.10	27.43
90	9.25	11.47	92.66	27.93	9.25	11.09	93.29	27.54
91	10.40	14.20	91.92	27.17	10.45	13.88	92.56	26.80
92	9.32	18.39	99.92	38.34	9.32	17.77	100.38	37.86

93	10.52	23.42	97.28	33.75	10.58	22.86	97.81	33.32
94	12.19	28.23	93.82	29.22	12.29	27.97	94.43	28.83
95	6.70	4.84	101.55	42.95	6.67	4.78	101.95	42.42
96	9.36	25.26	105.84	60.83	9.36	24.40	106.12	60.09
97	10.62	32.85	103.43	49.49	10.67	32.08	103.78	48.88
98	12.10	39.50	99.42	38.00	12.20	39.09	99.89	37.53
99	7.35	12.99	106.29	98.27	7.31	12.71	106.51	97.13
100	7.03	20.92	105.96	204.30	6.99	20.57	106.15	201.93
101	6.20	19.39	102.41	233.69	6.20	19.25	102.61	230.84
102	6.00	22.27	97.05	195.58	6.00	22.13	97.29	193.65
103	5.61	0.46	88.48	18.27	5.56	0.48	90.12	19.29
104	7.86	3.16	88.44	18.19	7.83	3.29	90.08	19.22
105	8.57	4.08	88.51	18.19	8.51	4.19	90.16	19.20
106	9.95	4.72	88.59	18.19	9.85	4.78	90.25	19.20
107	11.75	11.51	88.93	18.38	11.75	11.75	90.58	19.40
108	5.53	1.32	91.78	20.35	5.49	1.38	93.28	21.49
109	7.78	8.21	91.73	20.27	7.75	8.60	93.23	21.42
110	8.64	11.07	91.07	19.71	8.57	11.36	92.62	20.82
111	10.00	13.05	90.80	19.51	9.94	13.25	92.38	20.60
112	8.69	17.73	99.54	28.15	8.62	18.14	100.62	29.77
113	10.13	21.38	98.71	26.96	10.07	21.70	99.85	28.49
114	11.99	25.67	95.43	23.33	12.00	26.21	96.76	24.67
115	7.03	6.50	103.40	37.73	7.02	6.89	104.15	39.89
116	8.74	24.17	105.73	45.78	8.66	24.73	106.33	48.44
117	7.39	17.32	107.46	96.15	7.37	18.29	107.79	101.20
118	8.82	36.10	106.88	96.75	8.75	36.82	107.39	101.63
119	7.23	25.86	107.65	209.10	7.21	27.44	107.99	219.85
120	6.77	19.87	103.60	242.97	6.76	21.44	103.85	246.55
121	8.88	65.42	100.87	179.01	8.80	66.75	101.32	180.83
122	6.42	19.81	100.23	248.62	6.41	21.61	100.89	253.23
123	6.37	0.16	47.28	6.80	6.31	0.17	51.47	7.35
124	7.63	0.80	47.28	6.80	7.70	0.87	51.44	7.34
125	10.79	2.17	47.28	6.80	10.64	2.16	51.45	7.32
126	11.79	3.47	47.28	6.80	11.79	3.48	51.46	7.32
127	12.84	8.53	47.29	6.80	12.86	8.71	51.51	7.34
128	6.39	0.46	47.39	6.84	6.33	0.48	52.10	7.47
129	7.55	2.25	47.39	6.84	7.62	2.39	52.12	7.47
130	10.29	5.34	47.42	6.84	10.21	5.42	52.20	7.47
131	11.67	8.67	47.37	6.82	11.65	8.83	51.92	7.42
132	10.13	8.41	48.35	7.16	10.09	8.61	56.62	8.48
133	11.70	14.07	47.98	7.03	11.69	14.35	54.73	8.04
134	6.85	2.08	48.62	7.31	6.84	2.14	58.27	8.96
135	10.08	11.49	50.68	8.13	10.05	11.78	65.58	11.17
136	7.06	5.36	51.30	12.17	7.08	5.52	68.92	17.77
137	10.00	15.69	51.45	17.86	9.96	16.20	68.60	25.66
138	6.92	8.59	50.51	27.08	6.92	8.89	68.08	39.42

	Line9				Line10			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.64	0.40	79.46	13.39	5.60	0.43	79.78	14.73
2	7.81	2.58	79.38	13.32	7.81	2.82	79.69	14.66
3	8.72	3.45	79.39	13.31	8.62	3.68	79.70	14.66
4	10.34	4.29	79.43	13.31	10.16	4.44	79.75	14.64
5	12.07	10.74	79.96	13.48	11.97	11.07	80.28	14.85
6	5.57	1.14	84.47	15.33	5.53	1.23	84.78	16.88
7	7.72	6.80	84.37	15.26	7.72	7.42	84.68	16.82
8	8.74	9.39	83.21	14.72	8.66	10.02	83.52	16.20
9	10.31	11.74	82.68	14.50	10.17	12.21	83.00	15.96
10	8.78	15.11	95.26	22.15	8.70	16.09	95.51	24.38
11	10.41	19.28	93.94	20.96	10.28	20.04	94.19	23.08
12	6.99	5.54	100.87	30.54	7.00	6.02	101.04	33.64
13	7.34	14.66	106.29	79.95	7.35	15.94	106.38	87.84
14	8.88	30.46	104.96	79.62	8.82	32.49	105.12	87.36
15	7.19	22.03	106.40	176.40	7.19	23.92	106.52	192.76
16	6.31	0.17	50.96	7.40	6.36	0.17	47.08	6.80
17	7.68	0.82	50.92	7.40	7.61	0.77	47.08	6.80
18	10.75	2.20	50.93	7.39	10.81	2.14	47.07	6.80
19	11.71	3.35	50.93	7.39	11.78	3.36	47.07	6.78
20	6.33	0.50	51.66	7.56	6.38	0.48	47.23	6.86
21	7.51	2.26	51.68	7.56	7.48	2.19	47.23	6.86
22	10.22	5.10	51.73	7.57	10.27	5.08	47.25	6.86
23	10.02	7.83	56.40	8.67	10.07	7.87	48.33	7.21
24	6.77	2.16	58.35	9.21	6.80	2.10	48.76	7.40
25	9.93	10.59	65.86	11.59	9.98	10.67	51.06	8.27
26	6.99	5.45	70.10	18.91	7.01	5.37	52.50	12.69
27	9.86	14.39	69.77	27.36	9.90	14.49	52.60	18.58
28	6.89	8.62	71.01	44.99	6.90	8.62	53.05	29.34
29	6.73	6.27	64.42	74.26	6.76	6.28	50.53	51.38
30	5.03	0.35	89.29	21.33	5.07	0.33	87.64	20.05
31	7.91	2.96	89.25	21.24	7.94	2.85	87.59	19.96
32	8.64	3.90	89.31	21.21	8.69	3.80	87.65	19.95
33	9.65	4.14	89.40	21.21	9.72	4.08	87.73	19.95
34	11.62	9.40	89.73	21.49	11.59	9.12	88.08	20.19
35	4.85	0.97	92.54	24.11	4.88	0.90	91.03	22.63
36	7.87	7.56	92.48	23.98	7.91	7.25	90.96	22.50
37	8.48	9.76	91.85	23.25	8.54	9.50	90.28	21.82
38	9.66	10.65	91.58	22.95	9.70	10.42	89.99	21.55
39	8.48	15.25	100.12	33.93	8.54	14.84	99.02	31.79
40	9.84	17.37	99.32	32.27	9.88	16.98	98.16	30.22
41	12.04	21.46	96.13	27.71	12.02	20.81	94.79	25.99
42	7.22	5.38	103.82	46.47	7.26	5.03	103.06	43.43
43	8.51	20.51	106.06	56.85	8.57	19.95	105.46	53.11
44	10.01	24.29	105.53	52.71	10.05	23.72	104.87	49.28
45	7.59	14.53	107.62	132.99	7.64	13.77	107.26	123.59

46	8.60	29.77	107.19	139.02	8.65	29.14	106.63	129.11
47	7.50	19.27	107.77	377.84	7.55	18.18	107.44	348.00
48	5.90	0.40	90.33	30.23	5.91	0.40	89.69	30.71
49	7.96	2.15	90.31	30.10	7.97	2.21	89.66	30.57
50	9.02	3.12	90.39	30.07	8.99	3.21	89.75	30.56
51	9.99	3.50	90.48	30.07	9.92	3.56	89.83	30.55
52	12.23	9.03	90.58	30.22	12.07	9.06	89.93	30.70
53	5.88	1.17	92.13	32.51	5.88	1.18	91.51	33.00
54	7.82	5.40	92.26	32.49	7.87	5.59	91.64	32.99
55	8.85	8.34	92.45	32.55	8.86	8.70	91.83	33.04
56	9.99	9.71	91.69	31.54	9.90	9.99	91.06	32.02
57	8.89	13.68	99.78	45.76	8.91	14.28	99.32	46.42
58	10.14	16.50	97.12	39.85	10.06	16.94	96.59	40.44
59	12.41	21.21	93.63	34.13	12.25	21.28	93.03	34.65
60	6.57	4.37	101.41	52.27	6.59	4.42	101.00	53.03
61	8.93	18.84	105.77	75.02	8.95	19.68	105.49	76.06
62	10.29	23.48	103.35	59.81	10.20	24.09	102.99	60.64
63	7.05	10.39	106.37	139.58	7.09	10.60	106.15	141.57
64	9.04	29.08	107.43	205.83	9.05	30.47	107.19	208.78
65	5.02	0.26	82.10	12.86	5.01	0.29	82.47	14.28
66	7.97	2.43	82.02	12.80	7.95	2.63	82.39	14.22
67	8.93	3.43	82.03	12.80	8.81	3.61	82.41	14.20
68	10.14	3.91	82.08	12.79	9.95	4.01	82.46	14.20
69	11.92	8.82	82.70	13.03	11.80	9.02	83.08	14.46
70	4.83	0.73	87.69	15.32	4.83	0.81	88.03	17.03
71	7.93	6.14	87.59	15.23	7.91	6.66	87.93	16.93
72	8.73	8.38	86.35	14.56	8.63	8.88	86.70	16.19
73	10.09	9.77	85.78	14.27	9.93	10.09	86.14	15.86
74	8.71	12.99	98.21	23.32	8.62	13.80	98.44	25.96
75	10.27	15.85	97.02	21.87	10.10	16.39	97.27	24.32
76	12.34	20.05	92.70	18.21	12.23	20.53	93.00	20.23
77	7.29	4.22	102.83	33.25	7.27	4.65	102.98	37.05
78	8.73	17.46	105.15	40.80	8.64	18.55	105.27	45.49
79	10.44	22.19	104.47	37.39	10.27	22.93	104.60	41.67
80	12.31	28.22	101.75	29.69	12.20	28.89	101.92	33.05
81	7.66	11.64	106.92	96.31	7.63	12.72	106.98	107.97
82	7.58	15.44	107.23	264.39	7.54	16.89	107.28	300.03
83	6.31	0.17	53.06	6.48	6.37	0.16	47.52	5.84
84	7.70	0.88	53.04	6.48	7.63	0.80	47.52	5.82
85	10.63	2.16	53.05	6.47	10.78	2.17	47.52	5.82
86	11.78	3.48	53.06	6.47	11.79	3.47	47.52	5.82
87	12.86	8.71	53.13	6.48	12.84	8.53	47.54	5.82
88	6.33	0.48	53.89	6.63	6.39	0.47	47.68	5.87
89	7.62	2.41	53.92	6.63	7.55	2.26	47.69	5.87
90	10.20	5.43	54.00	6.65	10.28	5.35	47.72	5.87
91	11.65	8.83	53.65	6.58	11.66	8.68	47.65	5.84
92	10.08	8.62	59.35	7.75	10.13	8.43	48.95	6.24

93	11.68	14.35	57.16	7.27	11.70	14.08	48.49	6.10
94	13.08	19.46	54.79	6.79	13.07	19.08	47.93	5.92
95	6.85	2.14	61.37	8.28	6.85	2.08	49.36	6.44
96	10.05	11.80	69.23	10.60	10.08	11.51	51.84	7.31
97	11.73	20.13	64.83	9.20	11.75	19.75	50.64	6.81
98	13.01	27.21	59.56	7.79	13.01	26.71	49.18	6.27
99	7.08	5.54	72.75	17.12	7.06	5.38	52.77	11.16
100	6.92	8.96	72.38	37.84	6.93	8.66	52.29	24.77
101	6.72	6.86	64.14	55.98	6.77	6.45	49.02	41.42
102	6.63	6.43	56.28	68.99	6.69	5.85	46.62	59.09
103	5.56	0.48	90.13	19.29	5.61	0.46	88.48	18.27
104	7.83	3.29	90.09	19.22	7.86	3.16	88.44	18.19
105	8.50	4.19	90.17	19.20	8.57	4.08	88.51	18.19
106	9.86	4.78	90.26	19.20	9.94	4.72	88.59	18.19
107	11.75	11.75	90.59	19.40	11.75	11.51	88.93	18.38
108	5.49	1.38	93.29	21.49	5.53	1.32	91.79	20.35
109	7.75	8.60	93.24	21.41	7.78	8.21	91.73	20.27
110	8.57	11.36	92.63	20.82	8.64	11.08	91.07	19.71
111	9.94	13.25	92.39	20.60	10.00	13.05	90.81	19.51
112	8.62	18.15	100.63	29.75	8.69	17.72	99.54	28.14
113	10.07	21.70	99.87	28.49	10.13	21.38	98.71	26.94
114	12.00	26.22	96.77	24.67	11.99	25.68	95.43	23.33
115	7.02	6.89	104.17	39.89	7.03	6.51	103.41	37.73
116	8.66	24.73	106.34	48.42	8.74	24.18	105.73	45.78
117	7.37	18.30	107.81	101.18	7.39	17.33	107.46	96.15
118	8.75	36.84	107.40	101.61	8.82	36.10	106.88	96.75
119	7.21	27.44	108.01	219.85	7.23	25.86	107.64	209.13
120	6.76	21.43	103.88	246.47	6.77	19.87	103.59	243.01
121	8.80	66.77	101.36	180.62	8.88	65.45	100.85	178.93
122	6.41	21.58	100.92	252.79	6.42	19.77	100.16	248.40
123	5.86	0.43	86.02	26.54	5.87	0.43	85.27	26.93
124	8.23	2.90	85.97	26.44	8.25	2.99	85.23	26.82
125	9.01	4.14	86.04	26.43	9.00	4.27	85.29	26.80
126	10.22	4.93	86.11	26.43	10.17	5.04	85.36	26.81
127	12.06	12.47	86.23	26.50	11.97	12.59	85.48	26.88
128	5.84	1.27	88.02	28.03	5.84	1.27	87.31	28.43
129	8.16	6.78	88.14	28.03	8.19	6.99	87.42	28.44
130	9.25	11.09	88.30	28.15	9.25	11.50	87.58	28.55
131	10.45	13.87	87.46	27.43	10.39	14.20	86.72	27.81
132	9.32	17.79	96.79	38.25	9.32	18.41	96.23	38.75
133	10.58	22.86	93.63	33.79	10.52	23.41	93.00	34.24
134	6.67	4.79	98.93	42.75	6.70	4.85	98.45	43.30
135	9.36	24.38	104.30	60.26	9.36	25.26	103.97	61.02
136	7.30	12.74	105.25	97.22	7.35	13.00	105.00	98.42
137	9.30	38.19	105.92	133.11	9.30	39.69	105.64	134.81
138	6.98	20.63	104.89	201.44	7.02	20.98	104.69	203.99

	Line11				Line12			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.57	0.45	80.05	15.95	5.53	0.48	81.04	16.91
2	7.81	3.03	79.96	15.89	7.80	3.20	80.97	16.83
3	8.55	3.90	79.98	15.87	8.49	4.05	80.98	16.83
4	10.01	4.58	80.02	15.88	9.91	4.68	81.03	16.82
5	11.88	11.38	80.55	16.08	11.85	11.66	81.56	17.04
6	5.50	1.30	85.04	18.29	5.46	1.37	86.00	19.40
7	7.73	7.98	84.95	18.21	7.71	8.41	85.91	19.32
8	8.60	10.61	83.79	17.57	8.54	11.01	84.77	18.63
9	10.05	12.66	83.27	17.29	9.97	12.96	84.26	18.34
10	8.64	17.00	95.72	26.43	8.58	17.62	96.46	28.08
11	10.18	20.76	94.42	25.04	10.10	21.25	95.19	26.59
12	7.01	6.46	101.20	36.46	7.00	6.86	101.71	38.76
13	7.35	17.11	106.46	94.97	7.34	18.12	106.71	100.75
14	8.77	34.37	105.25	94.32	8.71	35.55	105.61	99.79
15	7.20	25.66	106.67	207.79	7.18	27.26	106.94	219.95
16	6.35	0.17	47.09	6.83	6.29	0.18	50.95	7.36
17	7.50	0.74	47.09	6.83	7.45	0.74	50.93	7.36
18	10.85	2.10	47.09	6.82	10.82	2.07	50.93	7.35
19	11.84	3.38	47.09	6.82	11.87	3.40	50.94	7.35
20	6.37	0.48	47.15	6.86	6.31	0.50	51.41	7.47
21	7.44	2.14	47.15	6.86	7.41	2.17	51.42	7.48
22	10.30	5.09	47.15	6.85	10.29	5.15	51.44	7.48
23	10.11	7.95	47.51	7.09	10.12	8.12	54.48	8.25
24	6.80	2.09	47.73	7.22	6.77	2.14	56.06	8.69
25	10.03	10.82	48.42	7.80	10.05	11.08	61.07	10.36
26	7.00	5.36	49.10	11.67	6.98	5.46	64.72	16.59
27	9.94	14.65	48.85	16.90	9.96	15.00	63.63	23.42
28	6.88	8.71	49.01	26.21	6.85	8.98	64.73	36.94
29	6.74	6.52	47.60	45.92	6.68	6.97	59.11	57.20
30	5.10	0.30	86.26	18.54	5.12	0.27	85.55	16.74
31	7.98	2.71	86.21	18.45	8.00	2.53	85.49	16.67
32	8.76	3.68	86.25	18.45	8.87	3.52	85.54	16.65
33	9.83	4.02	86.33	18.44	10.00	3.93	85.61	16.64
34	11.63	8.90	86.69	18.66	11.73	8.70	85.98	16.85
35	4.91	0.83	89.75	20.89	4.92	0.75	89.09	18.85
36	7.95	6.85	89.68	20.79	7.98	6.36	89.02	18.73
37	8.61	9.15	88.96	20.15	8.70	8.67	88.28	18.19
38	9.79	10.17	88.66	19.90	9.95	9.86	87.97	17.95
39	8.61	14.28	98.08	29.28	8.69	13.49	97.59	26.37
40	9.96	16.55	97.16	27.86	10.12	16.02	96.65	25.09
41	12.04	20.25	93.64	23.97	12.16	19.80	93.05	21.61
42	7.29	4.67	102.40	39.96	7.32	4.26	102.05	35.93
43	8.64	19.22	104.93	48.80	8.72	18.14	104.65	43.85
44	10.13	23.12	104.30	45.30	10.28	22.39	104.00	40.74
45	7.68	12.89	106.93	112.96	7.71	11.85	106.77	100.93

46	8.71	28.17	106.15	117.92	8.78	26.60	105.90	105.22
47	7.60	16.95	107.16	314.89	7.64	15.54	107.04	278.10
48	5.91	0.40	89.25	30.86	5.91	0.40	89.61	30.52
49	7.99	2.25	89.22	30.71	7.98	2.21	89.58	30.38
50	8.98	3.27	89.31	30.70	9.00	3.21	89.66	30.35
51	9.89	3.60	89.39	30.70	9.92	3.57	89.74	30.34
52	11.96	9.08	89.49	30.84	12.05	9.04	89.85	30.49
53	5.88	1.18	91.09	33.16	5.88	1.17	91.42	32.79
54	7.89	5.68	91.22	33.14	7.87	5.55	91.55	32.77
55	8.88	8.93	91.40	33.19	8.87	8.71	91.73	32.82
56	9.87	10.16	90.63	32.18	9.90	10.00	90.97	31.82
57	8.92	14.65	98.99	46.59	8.91	14.30	99.21	46.06
58	10.02	17.23	96.23	40.59	10.06	16.96	96.49	40.13
59	12.16	21.32	92.61	34.80	12.23	21.22	92.93	34.40
60	6.60	4.44	100.72	53.22	6.59	4.40	100.90	52.63
61	8.96	20.17	105.28	76.31	8.96	19.71	105.39	75.43
62	10.15	24.48	102.74	60.83	10.20	24.11	102.89	60.12
63	7.12	10.71	105.99	142.04	7.10	10.57	106.07	140.34
64	9.06	31.31	107.01	209.43	9.06	30.53	107.11	206.82
65	5.01	0.32	82.79	15.60	4.99	0.34	83.82	16.65
66	7.93	2.80	82.71	15.54	7.90	2.93	83.74	16.58
67	8.72	3.76	82.73	15.51	8.66	3.89	83.76	16.56
68	9.80	4.09	82.78	15.51	9.71	4.17	83.82	16.56
69	11.70	9.22	83.39	15.80	11.68	9.48	84.43	16.88
70	4.83	0.89	88.31	18.62	4.82	0.96	89.26	19.92
71	7.89	7.13	88.22	18.50	7.86	7.51	89.17	19.79
72	8.55	9.35	87.00	17.69	8.49	9.70	87.98	18.90
73	9.79	10.40	86.44	17.32	9.71	10.67	87.44	18.52
74	8.54	14.57	98.64	28.39	8.49	15.12	99.29	30.45
75	9.97	16.93	97.48	26.61	9.90	17.40	98.18	28.52
76	12.13	21.03	93.25	22.13	12.11	21.64	94.08	23.69
77	7.24	5.03	103.10	40.60	7.22	5.38	103.54	43.59
78	8.57	19.57	105.36	49.87	8.51	20.31	105.71	53.59
79	10.14	23.67	104.71	45.67	10.07	24.33	105.09	49.05
80	12.10	29.57	102.07	36.18	12.08	30.42	102.56	38.84
81	7.61	13.70	107.04	118.96	7.58	14.53	107.25	128.44
82	7.52	18.23	107.31	333.92	7.48	19.40	107.50	363.63
83	6.36	0.17	47.18	5.90	6.29	0.17	52.04	6.61
84	7.53	0.73	47.17	5.90	7.48	0.71	52.00	6.61
85	10.89	2.19	47.17	5.89	10.92	2.22	52.01	6.61
86	11.78	3.46	47.17	5.89	11.75	3.46	52.02	6.61
87	12.83	8.40	47.18	5.89	12.84	8.32	52.05	6.61
88	6.38	0.47	47.26	5.95	6.31	0.50	52.67	6.76
89	7.47	2.14	47.26	5.95	7.40	2.10	52.68	6.75
90	10.35	5.28	47.26	5.95	10.36	5.25	52.70	6.75
91	11.68	8.55	47.22	5.91	11.68	8.45	52.40	6.70
92	10.16	8.25	47.77	6.21	10.15	8.14	56.63	7.68

93	11.71	13.83	47.50	6.08	11.72	13.67	54.74	7.24
94	13.08	18.81	47.29	5.97	13.11	18.68	53.07	6.84
95	6.81	2.08	48.11	6.40	6.74	2.12	58.60	8.24
96	10.09	11.23	49.06	7.03	10.07	11.05	64.43	10.17
97	11.77	19.41	48.27	6.59	11.78	19.19	60.24	8.79
98	13.03	26.37	47.67	6.19	13.06	26.21	56.14	7.59
99	7.01	5.30	50.25	10.87	6.95	5.32	68.73	16.98
100	6.90	8.53	51.00	25.25	6.87	8.55	70.32	40.60
101	6.76	6.29	49.68	44.50	6.72	6.31	65.61	67.59
102	6.69	5.57	47.97	65.45	6.63	5.57	60.00	91.73
103	5.65	0.43	87.11	17.04	5.69	0.41	86.43	15.53
104	7.88	2.98	87.06	16.98	7.88	2.74	86.38	15.47
105	8.65	3.92	87.12	16.96	8.74	3.70	86.44	15.46
106	10.06	4.63	87.20	16.96	10.22	4.49	86.51	15.46
107	11.78	11.25	87.55	17.14	11.88	10.93	86.87	15.63
108	5.58	1.24	90.52	18.99	5.62	1.16	89.88	17.30
109	7.80	7.74	90.45	18.90	7.80	7.14	89.81	17.23
110	8.72	10.67	89.76	18.38	8.79	10.05	89.10	16.75
111	10.09	12.76	89.48	18.19	10.22	12.30	88.81	16.57
112	8.77	17.10	98.60	26.22	8.85	16.13	98.11	23.89
113	10.21	20.92	97.72	25.09	10.33	20.17	97.21	22.86
114	12.02	25.09	94.29	21.75	12.11	24.39	93.71	19.82
115	7.03	6.07	102.74	35.13	7.02	5.60	102.38	32.01
116	8.82	23.34	105.19	42.62	8.89	22.06	104.90	38.84
117	7.40	16.21	107.11	89.80	7.40	14.95	106.91	82.03
118	8.88	34.93	106.42	90.74	8.95	32.91	106.14	83.11
119	7.25	24.15	107.27	195.70	7.25	22.27	106.98	179.29
120	6.78	18.26	103.57	236.97	6.79	16.66	103.30	222.00
121	8.96	63.19	100.79	175.24	9.02	59.40	100.32	164.94
122	6.43	17.88	99.43	234.84	6.45	16.11	98.91	219.13
123	5.87	0.43	84.76	27.07	5.87	0.43	85.07	26.78
124	8.26	3.03	84.71	26.95	8.25	2.98	85.01	26.66
125	9.00	4.34	84.78	26.94	9.01	4.26	85.08	26.66
126	10.15	5.10	84.84	26.94	10.18	5.03	85.14	26.65
127	11.91	12.66	84.96	27.01	11.96	12.56	85.26	26.73
128	5.84	1.27	86.82	28.57	5.84	1.26	87.10	28.27
129	8.21	7.10	86.92	28.59	8.19	6.97	87.21	28.28
130	9.25	11.70	87.09	28.68	9.25	11.47	87.37	28.39
131	10.36	14.40	86.21	27.96	10.39	14.19	86.51	27.65
132	9.32	18.76	95.84	38.90	9.33	18.39	96.05	38.53
133	10.49	23.72	92.55	34.39	10.52	23.39	92.80	34.04
134	6.71	4.87	98.10	43.48	6.70	4.82	98.29	43.05
135	9.37	25.76	103.73	61.24	9.37	25.24	103.84	60.64
136	7.37	13.13	104.82	98.84	7.35	12.96	104.91	98.00
137	9.30	40.55	105.43	135.33	9.30	39.66	105.53	134.00
138	7.05	21.11	104.55	204.98	7.03	20.87	104.65	203.34

	Line13				Line14			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.54	0.48	81.04	16.91	5.57	0.45	80.04	15.95
2	7.80	3.20	80.96	16.83	7.81	3.03	79.95	15.89
3	8.49	4.05	80.98	16.83	8.55	3.90	79.97	15.87
4	9.91	4.68	81.03	16.81	10.01	4.58	80.01	15.88
5	11.85	11.66	81.55	17.04	11.88	11.38	80.54	16.08
6	5.46	1.37	86.00	19.40	5.50	1.30	85.03	18.29
7	7.71	8.42	85.90	19.32	7.73	7.97	84.93	18.21
8	8.54	11.01	84.76	18.61	8.60	10.61	83.78	17.56
9	9.97	12.96	84.25	18.34	10.05	12.66	83.26	17.29
10	8.58	17.62	96.46	28.08	8.64	17.00	95.71	26.42
11	10.10	21.26	95.20	26.59	10.17	20.76	94.41	25.02
12	7.00	6.86	101.73	38.75	7.01	6.46	101.20	36.46
13	7.34	18.13	106.73	100.70	7.35	17.12	106.47	94.94
14	8.71	35.56	105.62	99.75	8.77	34.39	105.25	94.29
15	7.18	27.26	106.95	219.86	7.20	25.67	106.66	207.74
16	5.87	0.43	85.22	26.81	5.87	0.43	84.85	27.09
17	8.25	2.98	85.17	26.69	8.26	3.03	84.80	26.96
18	9.01	4.26	85.24	26.69	9.01	4.34	84.87	26.95
19	10.17	5.03	85.31	26.69	10.14	5.10	84.93	26.95
20	5.84	1.26	87.25	28.30	5.84	1.27	86.90	28.58
21	8.19	6.97	87.35	28.30	8.21	7.09	87.00	28.59
22	9.25	11.47	87.52	28.41	9.25	11.71	87.17	28.70
23	9.32	18.40	96.13	38.52	9.32	18.76	95.89	38.91
24	6.70	4.83	98.36	43.04	6.71	4.88	98.15	43.48
25	9.37	25.27	103.88	60.61	9.37	25.76	103.75	61.23
26	7.35	12.95	104.93	97.87	7.37	13.14	104.83	98.78
27	9.30	39.66	105.55	133.94	9.30	40.56	105.45	135.28
28	7.03	20.88	104.64	202.95	7.05	21.13	104.55	204.75
29	6.21	19.36	100.67	232.60	6.21	19.48	100.52	234.68
30	5.69	0.41	86.44	15.54	5.65	0.43	87.12	17.03
31	7.88	2.74	86.39	15.47	7.87	2.98	87.07	16.98
32	8.74	3.69	86.45	15.46	8.65	3.92	87.13	16.96
33	10.22	4.49	86.52	15.46	10.06	4.63	87.21	16.96
34	11.88	10.93	86.88	15.63	11.78	11.25	87.56	17.14
35	5.62	1.16	89.89	17.30	5.58	1.24	90.52	18.99
36	7.80	7.13	89.82	17.23	7.80	7.74	90.46	18.90
37	8.80	10.04	89.12	16.75	8.72	10.67	89.77	18.38
38	10.22	12.30	88.82	16.57	10.09	12.76	89.48	18.19
39	8.85	16.13	98.13	23.88	8.77	17.09	98.61	26.22
40	10.33	20.17	97.23	22.86	10.21	20.92	97.73	25.09
41	12.10	24.38	93.73	19.81	12.02	25.08	94.30	21.75
42	7.02	5.60	102.41	32.01	7.03	6.07	102.75	35.13
43	8.89	22.06	104.93	38.83	8.82	23.34	105.21	42.63
44	10.44	28.21	104.29	36.44	10.32	29.22	104.59	40.00
45	7.40	14.96	106.94	82.03	7.40	16.22	107.13	89.80

46	8.95	32.90	106.17	83.08	8.88	34.92	106.44	90.72
47	7.25	22.26	107.03	179.22	7.25	24.13	107.29	195.65
48	6.30	0.17	51.53	6.60	6.36	0.16	47.04	5.94
49	7.48	0.71	51.50	6.59	7.53	0.73	47.03	5.94
50	10.92	2.22	51.50	6.58	10.89	2.18	47.03	5.94
51	11.76	3.45	51.50	6.59	11.79	3.46	47.03	5.94
52	12.84	8.31	51.54	6.59	12.84	8.39	47.03	5.92
53	6.31	0.50	52.17	6.75	6.38	0.47	47.11	5.97
54	7.40	2.09	52.18	6.75	7.47	2.13	47.11	5.97
55	10.37	5.25	52.18	6.74	10.35	5.27	47.10	5.97
56	11.68	8.44	51.88	6.67	11.68	8.54	47.07	5.94
57	10.16	8.12	56.06	7.65	10.16	8.23	47.55	6.24
58	11.73	13.65	54.20	7.21	11.72	13.82	47.31	6.11
59	13.11	18.65	52.55	6.83	13.09	18.79	47.13	6.00
60	6.74	2.11	58.11	8.22	6.81	2.07	47.90	6.43
61	10.08	11.03	63.74	10.11	10.10	11.21	48.66	7.05
62	11.79	19.16	59.64	8.74	11.77	19.39	47.96	6.59
63	6.95	5.30	68.14	16.96	7.01	5.27	49.77	10.91
64	10.03	14.88	66.91	23.62	10.02	15.20	49.12	15.51
65	4.99	0.34	83.84	16.65	5.01	0.32	82.81	15.60
66	7.90	2.94	83.77	16.59	7.93	2.80	82.73	15.54
67	8.66	3.89	83.79	16.56	8.72	3.77	82.75	15.51
68	9.71	4.17	83.84	16.56	9.80	4.09	82.79	15.51
69	11.68	9.48	84.45	16.88	11.70	9.23	83.42	15.80
70	4.82	0.96	89.28	19.92	4.83	0.89	88.34	18.62
71	7.86	7.51	89.19	19.79	7.89	7.14	88.24	18.50
72	8.49	9.70	88.01	18.90	8.55	9.36	87.03	17.69
73	9.71	10.68	87.46	18.52	9.79	10.40	86.46	17.32
74	8.49	15.12	99.32	30.45	8.54	14.57	98.66	28.39
75	9.90	17.40	98.22	28.52	9.96	16.93	97.51	26.61
76	12.11	21.65	94.11	23.69	12.13	21.04	93.27	22.13
77	7.22	5.38	103.58	43.59	7.24	5.04	103.13	40.60
78	8.51	20.33	105.76	53.59	8.57	19.58	105.40	49.87
79	10.07	24.34	105.13	49.05	10.14	23.67	104.74	45.67
80	12.08	30.43	102.60	38.84	12.10	29.58	102.10	36.19
81	7.58	14.54	107.29	128.45	7.61	13.70	107.07	118.99
82	7.48	19.41	107.56	363.62	7.52	18.24	107.37	333.94
83	5.91	0.40	89.42	30.48	5.91	0.40	89.16	30.84
84	7.98	2.21	89.39	30.33	7.99	2.25	89.13	30.70
85	8.99	3.22	89.48	30.32	8.98	3.27	89.21	30.69
86	9.92	3.57	89.56	30.31	9.89	3.61	89.29	30.68
87	12.05	9.04	89.66	30.46	11.97	9.08	89.39	30.83
88	5.88	1.17	91.25	32.76	5.88	1.18	91.01	33.15
89	7.87	5.59	91.38	32.74	7.89	5.69	91.13	33.13
90	8.87	8.73	91.56	32.79	8.88	8.93	91.32	33.17
91	9.90	10.00	90.80	31.77	9.87	10.16	90.54	32.15
92	8.91	14.31	99.11	46.03	8.92	14.65	98.94	46.58

93	10.06	16.96	96.35	40.10	10.02	17.23	96.15	40.57
94	12.23	21.22	92.76	34.38	12.15	21.31	92.53	34.79
95	6.59	4.41	100.82	52.57	6.60	4.44	100.68	53.20
96	8.96	19.71	105.35	75.38	8.96	20.19	105.26	76.28
97	10.20	24.11	102.83	60.09	10.16	24.48	102.71	60.81
98	12.11	29.92	98.61	45.40	12.03	30.05	98.44	45.95
99	7.10	10.58	106.03	140.24	7.12	10.72	105.98	141.98
100	6.87	15.01	105.37	387.72	6.89	15.08	105.30	392.94
101	6.22	11.28	101.48	674.31	6.22	11.33	101.35	683.40
102	6.07	10.17	96.28	883.58	6.07	10.20	95.99	895.15
103	5.12	0.27	85.53	16.74	5.10	0.30	86.25	18.54
104	8.00	2.53	85.47	16.67	7.98	2.71	86.19	18.45
105	8.87	3.52	85.52	16.65	8.76	3.68	86.24	18.45
106	10.00	3.93	85.59	16.64	9.83	4.02	86.31	18.44
107	11.73	8.70	85.95	16.85	11.62	8.89	86.67	18.66
108	4.92	0.75	89.07	18.85	4.90	0.83	89.73	20.91
109	7.98	6.35	89.00	18.76	7.95	6.85	89.67	20.79
110	8.70	8.66	88.26	18.19	8.61	9.15	88.95	20.18
111	9.95	9.86	87.96	17.97	9.80	10.17	88.65	19.91
112	8.69	13.48	97.56	26.37	8.61	14.28	98.06	29.27
113	10.12	16.01	96.62	25.10	9.97	16.54	97.15	27.86
114	12.16	19.79	93.02	21.61	12.04	20.25	93.63	23.99
115	7.32	4.26	102.02	35.92	7.29	4.67	102.37	39.96
116	8.72	18.14	104.62	43.85	8.64	19.21	104.91	48.82
117	7.71	11.85	106.73	100.95	7.68	12.88	106.91	112.98
118	8.78	26.59	105.86	105.25	8.71	28.16	106.13	117.91
119	7.64	15.54	106.99	278.11	7.60	16.95	107.14	314.90
120	6.98	9.41	102.66	440.66	6.96	10.29	102.99	504.26
121	8.97	44.15	99.55	334.31	8.90	46.63	99.85	380.65
122	6.26	7.03	98.45	612.43	6.26	7.75	98.66	697.09
123	6.29	0.18	50.75	7.37	6.35	0.17	46.97	6.88
124	7.44	0.74	50.72	7.35	7.49	0.73	46.97	6.86
125	10.82	2.07	50.73	7.35	10.86	2.09	46.97	6.86
126	11.87	3.40	50.74	7.35	11.84	3.38	46.97	6.86
127	12.95	8.57	50.76	7.35	12.91	8.32	46.97	6.85
128	6.31	0.50	51.21	7.47	6.37	0.48	47.02	6.90
129	7.41	2.17	51.21	7.47	7.43	2.14	47.02	6.90
130	10.29	5.14	51.23	7.47	10.30	5.08	47.02	6.88
131	11.75	8.56	51.02	7.42	11.73	8.35	47.00	6.88
132	10.11	8.12	54.20	8.22	10.11	7.95	47.32	7.11
133	11.77	13.87	52.75	7.86	11.76	13.50	47.16	7.01
134	6.77	2.15	55.80	8.68	6.80	2.10	47.54	7.27
135	10.05	11.08	60.66	10.30	10.03	10.81	48.10	7.78
136	6.98	5.47	64.30	16.55	7.00	5.37	48.67	11.68
137	9.96	14.99	62.56	23.07	9.94	14.63	48.06	16.82
138	6.85	9.02	63.94	36.70	6.88	8.75	48.20	26.21

	Line15				Line16			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.60	0.43	79.76	14.73	5.64	0.40	79.44	13.39
2	7.81	2.82	79.68	14.66	7.81	2.58	79.35	13.32
3	8.62	3.68	79.69	14.66	8.72	3.45	79.37	13.31
4	10.16	4.44	79.73	14.64	10.34	4.29	79.41	13.31
5	11.97	11.07	80.26	14.85	12.07	10.74	79.93	13.48
6	5.53	1.23	84.76	16.88	5.58	1.14	84.44	15.33
7	7.72	7.42	84.65	16.82	7.72	6.80	84.33	15.26
8	8.66	10.02	83.50	16.20	8.74	9.39	83.17	14.72
9	10.17	12.21	82.98	15.96	10.31	11.74	82.65	14.50
10	8.70	16.09	95.49	24.38	8.78	15.10	95.23	22.15
11	10.28	20.04	94.18	23.08	10.41	19.28	93.90	20.96
12	7.00	6.02	101.04	33.64	6.99	5.54	100.84	30.54
13	7.35	15.94	106.37	87.82	7.34	14.67	106.25	79.96
14	8.82	32.51	105.10	87.34	8.88	30.48	104.92	79.63
15	7.19	23.93	106.49	192.74	7.19	22.04	106.33	176.41
16	5.87	0.43	85.29	26.94	5.86	0.43	85.96	26.53
17	8.25	2.99	85.24	26.82	8.23	2.91	85.91	26.43
18	9.00	4.27	85.31	26.81	9.01	4.13	85.98	26.41
19	10.17	5.04	85.38	26.81	10.23	4.92	86.05	26.42
20	5.84	1.27	87.33	28.43	5.84	1.27	87.97	28.03
21	8.19	6.99	87.44	28.45	8.16	6.78	88.08	28.04
22	9.25	11.50	87.60	28.55	9.25	11.10	88.25	28.14
23	9.32	18.41	96.24	38.76	9.32	17.78	96.76	38.25
24	6.70	4.85	98.47	43.29	6.67	4.79	98.92	42.74
25	9.36	25.26	103.98	61.01	9.36	24.39	104.30	60.26
26	7.35	13.01	105.01	98.41	7.31	12.74	105.26	97.26
27	9.30	39.70	105.65	134.80	9.30	38.22	105.93	133.14
28	7.02	20.97	104.71	203.93	6.99	20.61	104.92	201.59
29	6.20	19.49	100.67	233.65	6.20	19.31	100.90	230.82
30	5.61	0.46	88.49	18.27	5.56	0.48	90.13	19.29
31	7.86	3.15	88.44	18.19	7.83	3.29	90.09	19.22
32	8.57	4.08	88.51	18.19	8.50	4.19	90.16	19.20
33	9.94	4.72	88.59	18.19	9.85	4.78	90.25	19.20
34	11.75	11.51	88.94	18.38	11.75	11.75	90.58	19.40
35	5.53	1.32	91.79	20.35	5.49	1.38	93.29	21.49
36	7.78	8.21	91.73	20.27	7.75	8.60	93.24	21.42
37	8.64	11.08	91.08	19.71	8.57	11.36	92.63	20.82
38	10.00	13.05	90.80	19.51	9.94	13.25	92.38	20.60
39	8.69	17.72	99.54	28.15	8.62	18.14	100.62	29.77
40	10.13	21.38	98.71	26.96	10.07	21.70	99.85	28.49
41	11.99	25.68	95.43	23.33	12.00	26.21	96.76	24.67
42	7.03	6.50	103.41	37.73	7.02	6.89	104.15	39.89
43	8.74	24.17	105.73	45.78	8.66	24.73	106.33	48.44
44	10.24	29.85	105.16	42.99	10.19	30.26	105.81	45.48
45	7.39	17.33	107.46	96.15	7.37	18.29	107.79	101.20

46	8.82	36.10	106.88	96.75	8.75	36.82	107.39	101.63
47	7.23	25.86	107.65	209.10	7.21	27.44	108.00	219.86
48	6.37	0.16	47.59	5.90	6.31	0.17	53.06	6.56
49	7.63	0.80	47.58	5.89	7.70	0.87	53.01	6.55
50	10.79	2.17	47.58	5.89	10.64	2.16	53.03	6.55
51	11.79	3.47	47.59	5.89	11.79	3.48	53.05	6.53
52	12.84	8.53	47.60	5.89	12.86	8.71	53.10	6.56
53	6.39	0.46	47.73	5.94	6.33	0.48	53.83	6.70
54	7.55	2.25	47.74	5.94	7.61	2.39	53.86	6.70
55	10.29	5.34	47.78	5.95	10.21	5.42	53.97	6.71
56	11.67	8.68	47.71	5.92	11.65	8.83	53.62	6.65
57	10.13	8.41	48.95	6.31	10.09	8.61	59.21	7.83
58	11.70	14.07	48.50	6.15	11.69	14.35	57.05	7.34
59	13.07	19.07	47.97	6.00	13.08	19.45	54.73	6.87
60	6.85	2.08	49.29	6.49	6.84	2.14	61.10	8.33
61	10.08	11.49	51.70	7.39	10.05	11.78	68.87	10.68
62	11.75	19.73	50.57	6.87	11.74	20.12	64.60	9.26
63	7.06	5.35	52.34	11.25	7.08	5.52	72.04	17.20
64	10.00	15.69	52.68	16.35	9.96	16.20	72.16	24.70
65	5.01	0.29	82.49	14.28	5.02	0.26	82.12	12.86
66	7.95	2.62	82.41	14.22	7.97	2.43	82.03	12.80
67	8.81	3.61	82.42	14.20	8.93	3.43	82.04	12.79
68	9.95	4.01	82.47	14.20	10.13	3.92	82.09	12.79
69	11.80	9.02	83.09	14.46	11.92	8.82	82.72	13.03
70	4.83	0.81	88.04	17.03	4.83	0.73	87.70	15.32
71	7.91	6.66	87.94	16.93	7.93	6.14	87.60	15.23
72	8.63	8.88	86.73	16.19	8.73	8.38	86.37	14.56
73	9.93	10.09	86.15	15.87	10.10	9.77	85.79	14.27
74	8.62	13.81	98.45	25.96	8.71	13.00	98.21	23.32
75	10.10	16.40	97.29	24.32	10.27	15.86	97.03	21.87
76	12.23	20.54	93.01	20.25	12.34	20.06	92.71	18.21
77	7.27	4.65	102.99	37.05	7.29	4.23	102.83	33.25
78	8.64	18.56	105.29	45.49	8.73	17.46	105.15	40.79
79	10.27	22.94	104.61	41.67	10.43	22.19	104.46	37.42
80	12.20	28.89	101.94	33.05	12.31	28.22	101.75	29.70
81	7.63	12.72	107.00	108.00	7.66	11.65	106.92	96.34
82	7.54	16.91	107.32	300.10	7.58	15.45	107.25	264.49
83	5.91	0.40	89.68	30.70	5.90	0.40	90.42	30.26
84	7.97	2.21	89.66	30.56	7.96	2.15	90.41	30.12
85	8.99	3.21	89.74	30.55	9.01	3.12	90.50	30.11
86	9.92	3.56	89.82	30.55	9.99	3.50	90.58	30.10
87	12.08	9.07	89.93	30.70	12.23	9.03	90.68	30.25
88	5.88	1.18	91.51	33.00	5.88	1.17	92.22	32.53
89	7.87	5.59	91.64	32.99	7.83	5.40	92.35	32.51
90	8.86	8.70	91.82	33.04	8.85	8.34	92.54	32.56
91	9.91	9.98	91.06	32.03	9.98	9.71	91.80	31.56
92	8.91	14.28	99.32	46.41	8.89	13.67	99.85	45.77

93	10.06	16.95	96.59	40.44	10.14	16.50	97.19	39.87
94	12.25	21.28	93.02	34.64	12.41	21.21	93.71	34.16
95	6.59	4.42	101.01	53.02	6.57	4.37	101.46	52.31
96	8.95	19.67	105.50	76.05	8.93	18.83	105.81	75.06
97	10.20	24.10	103.00	60.64	10.29	23.48	103.40	59.83
98	12.12	29.98	98.83	45.81	12.27	29.84	99.36	45.19
99	7.09	10.60	106.16	141.56	7.05	10.38	106.40	139.66
100	6.87	15.03	105.48	391.89	6.83	14.79	105.71	386.34
101	6.21	11.32	101.55	681.47	6.21	11.26	101.84	671.70
102	6.07	10.19	96.20	892.54	6.07	10.14	96.58	880.12
103	5.07	0.33	87.64	20.07	5.03	0.35	89.29	21.33
104	7.94	2.85	87.58	19.96	7.91	2.96	89.25	21.24
105	8.69	3.80	87.64	19.95	8.64	3.89	89.31	21.21
106	9.72	4.08	87.72	19.95	9.65	4.14	89.39	21.21
107	11.59	9.12	88.07	20.19	11.62	9.40	89.73	21.49
108	4.88	0.90	91.02	22.65	4.85	0.97	92.54	24.11
109	7.91	7.24	90.96	22.52	7.87	7.56	92.48	23.98
110	8.54	9.50	90.27	21.82	8.48	9.76	91.84	23.25
111	9.70	10.42	89.99	21.55	9.66	10.65	91.58	22.96
112	8.54	14.83	99.02	31.79	8.48	15.24	100.12	33.93
113	9.88	16.97	98.16	30.24	9.84	17.37	99.32	32.27
114	12.02	20.80	94.78	25.99	12.04	21.45	96.13	27.71
115	7.26	5.04	103.05	43.45	7.22	5.37	103.82	46.47
116	8.57	19.95	105.45	53.11	8.51	20.49	106.07	56.85
117	7.64	13.76	107.25	123.59	7.59	14.53	107.63	132.99
118	8.65	29.13	106.63	129.11	8.60	29.76	107.20	139.02
119	7.55	18.17	107.44	347.97	7.50	19.27	107.78	377.78
120	6.93	11.13	103.43	561.81	6.91	11.92	103.94	612.81
121	8.85	48.20	100.60	423.02	8.81	49.30	101.51	461.39
122	6.25	8.51	99.28	775.12	6.25	9.28	100.07	849.48
123	6.36	0.17	47.12	6.88	6.31	0.18	51.13	7.53
124	7.60	0.77	47.11	6.88	7.67	0.81	51.11	7.51
125	10.81	2.14	47.11	6.86	10.75	2.20	51.11	7.50
126	11.78	3.36	47.11	6.86	11.71	3.35	51.12	7.50
127	12.88	8.13	47.12	6.86	12.86	8.02	51.16	7.51
128	6.38	0.48	47.25	6.92	6.33	0.50	51.81	7.68
129	7.47	2.18	47.25	6.92	7.50	2.26	51.82	7.68
130	10.27	5.07	47.27	6.92	10.22	5.10	51.89	7.68
131	11.69	8.19	47.22	6.91	11.66	8.09	51.59	7.62
132	10.07	7.86	48.33	7.27	10.02	7.83	56.47	8.77
133	11.73	13.21	47.90	7.13	11.71	13.04	54.51	8.30
134	6.80	2.11	48.68	7.46	6.77	2.16	58.23	9.32
135	9.98	10.66	51.00	8.34	9.93	10.58	65.76	11.70
136	7.00	5.38	52.13	12.77	6.98	5.46	69.56	19.02
137	9.90	14.46	52.43	18.90	9.87	14.36	69.43	27.85
138	6.89	8.66	52.25	29.57	6.88	8.68	69.89	45.32

Appendix C: Data of mooring line tensions of designed mooring system C

	Line1				Line2			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.80	0.59	146.59	8.02	5.81	0.63	147.42	8.93
2	7.56	2.39	147.71	8.07	7.55	2.62	148.56	8.98
3	8.43	3.12	148.15	8.07	8.37	3.36	149.00	8.97
4	9.17	3.13	148.60	8.08	9.04	3.30	149.46	8.99
5	10.11	6.18	149.00	8.13	9.90	6.38	149.86	9.05
6	5.64	1.57	152.30	8.77	5.63	1.69	153.09	9.77
7	7.66	6.38	153.23	8.80	7.66	6.99	154.03	9.79
8	8.43	8.48	152.30	8.60	8.37	9.13	153.12	9.58
9	9.18	8.60	152.07	8.52	9.03	9.06	152.91	9.49
10	8.45	13.54	170.48	11.62	8.39	14.57	171.14	12.95
11	9.25	13.93	167.91	11.07	9.11	14.65	168.60	12.33
12	6.68	5.33	183.52	15.44	6.71	5.82	181.61	16.81
13	7.34	13.86	197.80	39.21	7.36	15.16	197.95	45.12
14	8.57	28.64	192.23	42.54	8.52	30.73	192.48	49.05
15	7.41	20.52	187.61	115.98	7.44	22.30	186.90	130.13
16	6.36	0.47	79.86	2.75	6.46	0.43	57.54	1.96
17	7.22	1.74	80.39	2.77	7.26	1.72	57.64	1.95
18	8.73	2.41	80.60	2.77	8.72	2.36	57.67	1.95
19	10.01	2.82	80.79	2.77	9.97	2.74	57.71	1.95
20	6.35	1.30	81.43	2.81	6.44	1.19	57.83	1.97
21	7.12	4.64	82.08	2.82	7.15	4.57	57.96	1.96
22	8.69	6.36	82.38	2.83	8.66	6.19	58.04	1.97
23	8.65	10.00	91.61	3.23	8.62	9.70	60.12	2.04
24	6.67	5.14	94.66	3.38	6.73	4.99	60.68	2.07
25	8.65	13.46	112.18	4.25	8.62	13.03	66.01	2.29
26	6.81	11.07	119.08	6.56	6.83	11.23	67.50	3.28
27	8.73	17.28	114.14	9.35	8.71	17.42	65.95	4.85
28	6.71	17.56	106.81	13.11	6.74	17.73	62.63	6.84
29	6.57	14.24	78.08	16.73	6.64	13.52	54.97	11.07
30	5.85	0.87	169.27	10.74	5.88	0.84	165.70	10.08
31	7.34	3.26	170.70	10.81	7.36	3.13	167.10	10.14
32	8.43	4.26	171.41	10.82	8.52	4.18	167.77	10.15
33	9.40	4.53	172.08	10.85	9.48	4.49	168.41	10.17
34	10.41	9.13	172.27	10.88	10.46	9.06	168.62	10.21
35	5.75	2.51	173.19	11.43	5.77	2.42	169.84	10.73
36	7.31	8.80	174.34	11.49	7.34	8.43	170.96	10.79
37	8.43	11.52	174.18	11.32	8.51	11.31	170.70	10.62
38	9.43	12.29	174.34	11.27	9.50	12.18	170.82	10.57
39	8.44	18.17	186.35	14.44	8.52	17.83	183.73	13.56
40	9.50	19.61	184.88	13.97	9.57	19.44	182.13	13.11
41	10.63	19.62	179.78	12.58	10.67	19.46	176.67	11.81
42	6.51	8.55	193.64	18.14	6.51	8.13	191.83	17.06
43	8.48	23.37	198.78	21.45	8.56	22.94	197.44	20.23
44	9.65	25.96	197.50	20.38	9.73	25.74	195.90	19.14

45	6.82	18.02	199.52	42.41	6.83	17.18	198.81	39.95
46	8.65	32.51	195.46	44.35	8.72	32.04	194.13	41.85
47	6.65	24.05	187.81	83.96	6.66	22.95	187.27	80.30
48	5.93	1.21	175.08	14.94	5.93	1.22	173.33	15.07
49	7.19	3.00	176.61	15.05	7.23	3.07	174.84	15.18
50	8.83	4.52	177.58	15.09	8.86	4.68	175.79	15.22
51	9.74	5.04	178.36	15.14	9.73	5.20	176.54	15.27
52	10.61	10.24	178.34	15.11	10.58	10.50	176.52	15.25
53	5.90	3.31	176.71	15.33	5.90	3.31	174.99	15.47
54	7.25	8.28	178.28	15.48	7.30	8.47	176.56	15.62
55	8.83	12.39	179.33	15.56	8.86	12.79	177.59	15.70
56	9.75	13.73	179.34	15.39	9.75	14.15	177.56	15.53
57	8.86	19.63	186.44	18.70	8.89	20.27	185.14	18.88
58	9.84	22.08	184.34	17.33	9.83	22.76	182.81	17.48
59	10.84	22.21	180.90	15.94	10.80	22.74	179.19	16.09
60	6.15	9.25	186.76	20.30	6.16	9.28	185.67	20.51
61	8.89	26.69	195.44	26.92	8.93	27.58	194.71	27.16
62	9.92	30.59	192.11	22.67	9.91	31.56	191.14	22.89
63	6.55	18.12	191.30	41.32	6.58	18.30	190.83	41.68
64	9.04	37.50	190.28	56.88	9.06	38.95	189.75	57.36
65	5.96	0.74	154.18	6.71	5.94	0.78	154.95	7.41
66	7.31	2.72	155.40	6.75	7.32	2.92	156.17	7.46
67	8.53	3.62	155.92	6.75	8.47	3.83	156.70	7.46
68	9.57	3.95	156.44	6.77	9.49	4.13	157.23	7.47
69	10.68	8.18	156.91	6.81	10.58	8.48	157.69	7.52
70	5.87	2.09	160.33	7.38	5.83	2.22	161.05	8.14
71	7.28	7.29	161.32	7.40	7.29	7.82	162.05	8.17
72	8.51	9.72	160.41	7.23	8.46	10.30	161.16	7.98
73	9.62	10.71	160.21	7.17	9.54	11.20	160.96	7.91
74	8.51	15.30	177.69	9.95	8.47	16.23	178.24	10.98
75	9.70	17.10	175.54	9.50	9.62	17.87	176.12	10.48
76	10.92	17.64	168.69	8.32	10.82	18.26	169.36	9.18
77	6.50	7.59	188.86	13.26	6.50	8.10	189.25	14.61
78	8.53	20.62	195.44	15.97	8.49	21.87	195.75	17.60
79	9.79	23.45	192.92	14.84	9.70	24.51	193.26	16.36
80	10.95	24.78	185.42	12.12	10.85	25.66	185.86	13.37
81	6.80	16.01	199.47	32.56	6.81	17.10	199.73	36.12
82	6.66	21.85	189.94	70.04	6.66	23.22	190.12	76.26
83	6.43	0.42	86.95	2.65	6.49	0.42	59.46	1.74
84	7.21	1.71	87.56	2.66	7.21	1.70	59.58	1.74
85	8.47	2.20	87.82	2.67	8.50	2.21	59.63	1.74
86	9.73	2.45	88.00	2.67	9.80	2.49	59.66	1.74
87	11.17	5.38	88.11	2.67	11.24	5.54	59.70	1.74
88	6.39	1.19	89.18	2.73	6.46	1.17	60.04	1.76
89	7.11	4.59	89.91	2.75	7.11	4.56	60.21	1.76
90	8.35	5.71	90.21	2.75	8.41	5.76	60.29	1.76
91	9.85	6.62	89.52	2.72	9.94	6.78	60.11	1.75

92	8.31	8.97	102.12	3.24	8.37	9.04	63.92	1.88
93	9.95	10.62	97.49	3.03	10.03	10.86	62.61	1.83
94	11.39	11.66	92.08	2.82	11.46	11.96	60.96	1.78
95	6.73	5.07	106.18	3.44	6.75	5.03	65.22	1.93
96	8.30	12.09	126.25	4.46	8.36	12.17	73.75	2.24
97	10.06	14.60	115.42	3.86	10.14	14.90	69.49	2.08
98	11.44	16.39	102.65	3.26	11.50	16.78	64.64	1.91
99	6.83	11.35	135.38	7.28	6.83	11.31	79.63	3.46
100	6.75	18.24	126.65	16.37	6.75	17.65	79.47	8.08
101	6.61	14.35	91.43	18.97	6.65	13.89	66.94	12.96
102	6.51	13.76	77.45	24.82	6.56	13.32	59.22	17.61
103	5.82	0.72	169.17	12.14	5.80	0.69	165.63	11.30
104	7.57	3.01	170.61	12.22	7.61	2.85	167.03	11.37
105	8.31	3.82	171.31	12.22	8.40	3.72	167.69	11.37
106	8.86	3.65	171.97	12.24	8.96	3.61	168.31	11.40
107	9.55	6.80	172.18	12.31	9.66	6.77	168.54	11.46
108	5.63	1.91	169.44	12.78	5.62	1.83	169.17	12.14
109	7.68	8.12	171.17	12.87	7.72	7.73	170.86	12.22
110	8.31	10.44	171.76	12.72	8.38	10.18	170.68	12.01
111	8.82	10.00	172.73	12.70	8.92	9.89	170.77	11.93
112	8.32	16.58	179.13	14.01	8.39	16.18	179.16	15.02
113	8.89	16.12	179.27	14.76	8.98	15.93	179.19	14.67
114	9.74	14.82	176.02	14.04	9.83	14.72	175.79	13.34
115	6.66	7.03	190.90	17.67	6.71	6.23	186.87	16.12
116	8.33	23.30	197.96	21.83	8.41	21.86	194.64	19.49
117	7.37	18.21	199.98	58.47	7.37	17.21	199.40	52.91
118	8.47	36.21	196.42	65.67	8.53	35.55	195.29	59.34
119	7.50	25.08	188.42	200.43	7.52	23.86	187.98	173.31
120	7.08	14.45	161.23	432.79	7.05	13.91	160.72	360.76
121	8.62	55.82	156.66	333.83	8.66	55.90	155.47	278.52
122	6.44	10.28	134.89	762.39	6.52	9.94	134.04	630.49
123	5.77	1.18	161.23	15.30	5.77	1.17	160.15	15.56
124	7.45	3.30	162.57	15.41	7.52	3.40	161.48	15.66
125	8.76	4.98	163.22	15.42	8.80	5.19	162.11	15.65
126	9.23	4.99	163.65	15.44	9.25	5.20	162.53	15.66
127	9.56	8.71	164.62	15.56	9.55	9.06	163.51	15.91
128	5.78	3.21	169.35	17.57	5.78	3.21	168.31	17.92
129	7.42	9.19	170.48	17.61	7.48	9.43	169.44	17.96
130	8.61	13.11	170.41	17.37	8.65	13.63	169.35	17.73
131	9.09	12.97	168.57	16.68	9.12	13.53	167.48	17.03
132	8.60	20.47	180.81	22.38	8.65	21.26	179.51	22.66
133	9.12	20.47	178.12	20.31	9.15	21.32	176.67	20.56
134	6.24	9.12	181.13	24.82	6.25	9.16	179.98	25.14
135	8.63	27.31	191.38	33.71	8.67	28.37	190.58	34.13
136	6.78	20.52	188.27	66.21	6.81	20.78	187.72	67.10
137	8.83	43.56	185.76	94.37	8.87	45.32	184.74	95.08
138	6.95	25.03	170.36	218.93	7.01	25.30	169.77	222.35

	Line3				Line4			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.82	0.68	148.13	9.77	5.83	0.72	150.52	10.51
2	7.55	2.82	149.27	9.82	7.53	3.00	151.69	10.56
3	8.32	3.58	149.73	9.82	8.25	3.73	152.17	10.56
4	8.94	3.46	150.19	9.84	8.84	3.56	152.65	10.58
5	9.73	6.58	150.59	9.91	9.61	6.70	153.04	10.65
6	5.63	1.81	153.77	10.69	5.64	1.91	156.04	11.51
7	7.66	7.55	154.71	10.72	7.64	8.01	157.01	11.54
8	8.33	9.75	153.82	10.48	8.27	10.15	156.18	11.28
9	8.93	9.50	153.61	10.39	8.83	9.77	156.00	11.17
10	8.34	15.52	171.06	14.12	8.29	16.14	170.13	14.88
11	8.99	15.35	169.18	13.50	8.90	15.77	169.72	14.39
12	6.73	6.27	179.19	16.49	6.76	6.71	179.26	16.08
13	7.37	16.36	198.07	50.86	7.33	18.15	198.52	56.21
14	8.48	34.00	192.69	55.39	8.44	35.21	193.54	61.31
15	7.45	23.89	187.85	160.75	7.44	25.24	188.54	189.13
16	6.48	0.41	57.95	2.00	6.40	0.42	80.46	2.87
17	7.25	1.71	58.02	2.00	7.23	1.71	80.92	2.88
18	8.66	2.31	58.03	2.00	8.59	2.27	81.09	2.88
19	9.92	2.65	58.06	2.00	9.85	2.57	81.26	2.89
20	6.45	1.16	58.23	2.01	6.36	1.19	81.94	2.94
21	7.14	4.54	58.31	2.01	7.11	4.56	82.48	2.95
22	8.59	6.00	58.32	2.01	8.49	5.84	82.65	2.95
23	8.55	9.38	59.83	2.07	8.44	9.13	90.88	3.33
24	6.75	4.95	60.70	2.11	6.72	5.03	94.44	3.52
25	8.54	12.60	64.34	2.27	8.43	12.27	109.94	4.34
26	6.84	11.15	68.91	3.44	6.82	11.23	120.28	7.09
27	8.64	16.75	67.89	5.15	8.55	16.25	116.36	10.27
28	6.76	17.41	70.04	8.02	6.74	18.08	115.39	15.99
29	6.64	13.78	64.18	13.49	6.59	14.42	88.09	18.66
30	5.90	0.81	162.67	9.33	5.93	0.77	161.16	8.46
31	7.37	2.97	164.04	9.38	7.37	2.77	162.52	8.52
32	8.59	4.06	164.68	9.39	8.65	3.86	163.14	8.52
33	9.55	4.41	165.29	9.41	9.63	4.23	163.74	8.54
34	10.52	8.91	165.51	9.44	10.61	8.62	163.97	8.57
35	5.81	2.31	166.98	9.93	5.84	2.18	165.54	9.02
36	7.35	8.00	168.08	9.98	7.35	7.47	166.64	9.06
37	8.58	10.96	167.74	9.83	8.63	10.38	166.26	8.92
38	9.58	11.93	167.81	9.79	9.66	11.44	166.32	8.88
39	8.59	17.28	181.45	12.55	8.64	16.37	180.29	11.40
40	9.65	19.04	179.75	12.13	9.73	18.27	178.54	11.02
41	10.73	19.13	173.99	10.93	10.82	18.51	172.65	9.92
42	6.45	8.12	190.19	15.80	6.45	7.61	189.34	14.36
43	8.63	22.23	196.17	18.74	8.66	22.10	195.50	17.04
44	9.73	26.14	194.49	17.71	9.81	25.08	193.75	16.10
45	6.80	17.21	198.17	37.10	6.80	16.12	197.72	33.45

46	8.78	31.07	192.95	38.94	8.79	30.82	192.31	35.56
47	6.64	23.38	186.71	75.44	6.65	21.99	186.37	69.56
48	5.93	1.21	172.15	15.09	5.93	1.21	172.92	14.97
49	7.26	3.10	173.65	15.21	7.24	3.06	174.43	15.09
50	8.88	4.76	174.58	15.24	8.87	4.67	175.37	15.12
51	9.74	5.29	175.32	15.29	9.74	5.19	176.12	15.17
52	10.56	10.64	175.30	15.27	10.58	10.48	176.10	15.15
53	5.90	3.31	173.84	15.49	5.90	3.27	174.60	15.36
54	7.33	8.55	175.40	15.64	7.31	8.43	176.15	15.52
55	8.88	13.01	176.41	15.72	8.87	12.76	177.18	15.59
56	9.75	14.38	176.36	15.55	9.76	14.13	177.14	15.42
57	8.91	20.62	184.21	18.90	8.90	20.23	184.73	18.72
58	9.83	23.15	181.77	17.50	9.84	22.73	182.42	17.36
59	10.78	23.05	178.04	16.11	10.80	22.71	178.78	15.97
60	6.17	9.27	184.89	20.53	6.16	9.22	185.32	20.33
61	8.95	28.07	194.19	27.19	8.93	27.52	194.50	26.97
62	9.92	32.10	190.43	22.91	9.92	31.51	190.81	22.68
63	6.60	18.36	190.50	41.75	6.58	18.21	190.72	41.44
64	9.08	39.74	189.38	57.44	9.07	38.86	189.64	57.02
65	5.91	0.82	155.60	8.05	5.89	0.86	157.94	8.60
66	7.32	3.10	156.83	8.10	7.32	3.25	159.19	8.65
67	8.43	4.03	157.36	8.10	8.36	4.15	159.76	8.65
68	9.42	4.30	157.90	8.11	9.35	4.39	160.31	8.67
69	10.50	8.75	158.35	8.17	10.44	8.91	160.75	8.72
70	5.80	2.35	161.66	8.84	5.78	2.46	163.83	9.44
71	7.29	8.31	162.66	8.87	7.28	8.73	164.85	9.47
72	8.42	10.84	161.79	8.66	8.36	11.19	164.05	9.25
73	9.47	11.65	161.60	8.59	9.40	11.90	163.90	9.17
74	8.43	17.08	178.70	11.92	8.37	17.62	180.32	12.73
75	9.54	18.59	176.61	11.38	9.47	18.99	178.33	12.15
76	10.73	18.84	169.92	9.97	10.67	19.18	171.90	10.65
77	6.49	8.57	189.57	15.85	6.49	9.02	190.66	16.92
78	8.45	23.02	196.00	19.09	8.42	22.63	196.84	20.38
79	9.63	25.49	193.54	17.76	9.56	26.03	194.47	18.96
80	10.76	26.47	186.22	14.51	10.71	26.94	187.47	15.50
81	6.81	18.10	199.94	39.46	6.84	17.96	200.34	42.12
82	6.66	24.48	190.27	81.72	6.67	23.91	190.64	86.23
83	6.46	0.44	58.21	1.70	6.35	0.48	84.62	2.53
84	7.19	1.70	58.29	1.70	7.14	1.72	85.15	2.54
85	8.52	2.22	58.31	1.70	8.52	2.25	85.34	2.54
86	9.87	2.54	58.35	1.70	9.92	2.61	85.57	2.55
87	11.31	5.72	58.34	1.70	11.35	5.92	85.56	2.55
88	6.44	1.22	58.41	1.71	6.34	1.34	86.15	2.58
89	7.08	4.55	58.51	1.70	7.04	4.61	86.76	2.60
90	8.45	5.82	58.54	1.70	8.47	5.93	87.01	2.60
91	10.02	6.95	58.45	1.70	10.07	7.17	86.46	2.58
92	8.41	9.14	59.90	1.75	8.43	9.33	96.00	2.96

93	10.11	11.14	59.21	1.73	10.16	11.50	91.92	2.79
94	11.52	12.33	58.62	1.71	11.56	12.76	87.94	2.63
95	6.72	5.09	60.56	1.78	6.65	5.27	99.54	3.12
96	8.40	12.31	63.83	1.91	8.42	12.58	115.70	3.87
97	10.21	15.27	61.37	1.81	10.26	15.76	105.25	3.36
98	11.56	17.25	59.58	1.75	11.59	17.84	95.03	2.91
99	6.81	11.40	65.56	2.76	6.77	11.23	123.08	6.06
100	6.71	18.03	61.44	5.84	6.67	17.87	111.45	12.14
101	6.63	13.78	55.91	9.83	6.55	14.62	85.48	15.62
102	6.57	12.74	52.79	13.79	6.50	13.12	69.17	17.19
103	5.78	0.65	162.60	10.36	5.77	0.60	161.07	9.32
104	7.63	2.67	163.97	10.42	7.64	2.44	162.42	9.37
105	8.48	3.57	164.59	10.43	8.54	3.33	163.03	9.37
106	9.07	3.51	165.20	10.45	9.18	3.34	163.61	9.39
107	9.79	6.68	165.44	10.50	9.98	6.46	163.86	9.44
108	5.62	1.74	166.99	11.17	5.62	1.63	165.54	10.04
109	7.74	7.26	168.08	11.21	7.74	6.66	166.62	10.07
110	8.45	9.78	167.72	11.01	8.51	9.13	166.22	9.89
111	9.03	9.64	167.77	10.94	9.15	9.17	166.25	9.82
112	8.46	15.56	180.02	14.15	8.51	14.56	180.36	12.85
113	9.09	15.53	179.80	13.75	9.21	14.80	178.59	12.35
114	9.96	14.50	174.01	12.30	10.14	14.06	172.66	11.05
115	6.67	5.79	185.10	15.76	6.63	5.34	187.33	16.11
116	8.48	21.04	191.33	17.49	8.53	19.71	192.75	18.23
117	7.41	15.43	198.88	47.00	7.39	14.18	198.66	40.82
118	8.58	34.35	194.30	52.61	8.62	30.97	193.85	45.58
119	7.53	22.45	187.04	142.22	7.50	20.77	186.97	118.45
120	6.99	13.36	160.23	295.62	6.88	12.75	159.55	227.61
121	8.70	55.15	154.39	229.20	8.73	52.91	152.67	175.78
122	6.58	9.45	133.41	500.05	6.56	8.95	133.35	380.25
123	5.77	1.16	159.08	15.61	5.77	1.17	159.45	15.38
124	7.54	3.44	160.39	15.71	7.53	3.39	160.77	15.48
125	8.82	5.30	161.01	15.70	8.81	5.19	161.39	15.49
126	9.27	5.33	161.42	15.69	9.26	5.21	161.81	15.51
127	9.55	9.27	162.40	15.95	9.56	9.07	162.79	15.67
128	5.78	3.20	167.30	17.97	5.78	3.19	167.66	17.68
129	7.51	9.56	168.41	18.01	7.48	9.41	168.77	17.72
130	8.68	13.93	168.31	17.77	8.66	13.63	168.67	17.48
131	9.13	13.85	166.40	17.08	9.12	13.53	166.78	16.79
132	8.67	21.71	178.62	22.70	8.65	21.25	179.28	22.45
133	9.16	21.82	175.69	20.60	9.15	21.33	176.42	20.37
134	6.25	9.16	179.20	25.18	6.25	9.12	179.79	24.90
135	8.70	28.98	190.03	34.18	8.68	28.36	190.43	33.78
136	6.83	20.91	187.34	67.18	6.81	20.73	187.63	66.37
137	8.89	46.34	184.28	95.18	8.87	45.34	184.98	94.45
138	7.04	25.48	169.50	222.72	7.02	25.30	169.98	219.52

	Line5				Line6			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.83	0.72	150.44	10.51	5.82	0.68	148.06	9.77
2	7.53	3.00	151.61	10.56	7.55	2.82	149.20	9.82
3	8.26	3.73	152.08	10.56	8.32	3.58	149.65	9.82
4	8.84	3.56	152.57	10.58	8.94	3.46	150.12	9.84
5	9.61	6.70	152.96	10.65	9.73	6.59	150.51	9.90
6	5.64	1.91	155.95	11.51	5.63	1.81	153.69	10.69
7	7.64	8.01	156.93	11.54	7.66	7.55	154.64	10.72
8	8.27	10.16	156.09	11.28	8.33	9.75	153.74	10.48
9	8.83	9.77	155.91	11.17	8.93	9.51	153.54	10.38
10	8.29	16.15	170.06	14.88	8.35	15.53	171.00	14.12
11	8.90	15.77	169.64	14.40	8.99	15.36	169.10	13.50
12	6.75	6.71	179.14	16.08	6.73	6.27	179.12	16.49
13	7.33	18.15	198.41	56.20	7.37	16.36	197.99	50.84
14	8.44	35.23	193.42	61.29	8.49	34.02	192.60	55.38
15	7.44	25.24	188.36	189.06	7.45	23.89	187.70	160.67
16	5.77	1.17	158.85	15.33	5.77	1.17	158.73	15.55
17	7.51	3.39	160.16	15.44	7.54	3.44	160.03	15.64
18	8.81	5.19	160.76	15.45	8.83	5.31	160.63	15.65
19	9.26	5.20	161.16	15.47	9.27	5.33	161.04	15.67
20	5.78	3.20	167.12	17.59	5.78	3.21	166.99	17.91
21	7.47	9.41	168.23	17.62	7.51	9.56	168.10	17.96
22	8.65	13.62	168.09	17.38	8.68	13.93	167.97	17.72
23	8.65	21.25	179.08	22.41	8.67	21.71	178.51	22.68
24	6.25	9.14	179.62	24.86	6.25	9.17	179.12	25.16
25	8.68	28.36	190.31	33.74	8.70	28.97	189.97	34.15
26	6.81	20.75	187.51	66.28	6.83	20.92	187.28	67.14
27	8.87	45.32	184.98	94.58	8.89	46.34	184.27	95.24
28	7.01	25.33	169.88	219.16	7.04	25.48	169.45	222.51
29	6.38	13.94	137.03	527.70	6.39	13.90	136.68	541.31
30	5.77	0.61	161.03	9.32	5.78	0.65	162.59	10.36
31	7.64	2.44	162.38	9.37	7.63	2.66	163.95	10.43
32	8.54	3.33	162.98	9.38	8.48	3.57	164.58	10.43
33	9.18	3.33	163.57	9.40	9.07	3.51	165.18	10.45
34	9.98	6.46	163.83	9.44	9.79	6.67	165.43	10.50
35	5.62	1.63	165.50	10.04	5.62	1.74	166.97	11.17
36	7.74	6.66	166.57	10.07	7.74	7.25	168.06	11.21
37	8.51	9.12	166.17	9.90	8.45	9.77	167.70	11.01
38	9.15	9.16	166.20	9.83	9.03	9.63	167.75	10.94
39	8.51	14.55	180.30	12.85	8.46	15.55	180.00	14.15
40	9.21	14.79	178.53	12.36	9.09	15.53	179.77	13.76
41	10.14	14.05	172.60	11.05	9.96	14.50	173.99	12.30
42	6.63	5.34	187.27	16.12	6.67	5.79	185.08	15.78
43	8.53	19.70	192.68	18.25	8.48	21.03	191.29	17.49
44	9.28	20.31	192.68	18.16	9.16	21.30	190.89	18.32
45	7.39	14.18	198.56	40.85	7.41	15.43	198.84	47.02

46	8.62	30.96	193.78	45.60	8.58	34.33	194.27	52.63
47	7.50	20.76	186.91	118.55	7.53	22.45	187.03	142.29
48	6.35	0.48	83.58	2.53	6.46	0.44	57.66	1.71
49	7.14	1.72	84.10	2.54	7.19	1.70	57.73	1.71
50	8.52	2.25	84.39	2.54	8.52	2.22	57.79	1.71
51	9.92	2.61	84.58	2.54	9.87	2.54	57.81	1.71
52	11.35	5.92	84.58	2.54	11.31	5.71	57.80	1.71
53	6.34	1.34	85.19	2.58	6.44	1.22	57.90	1.72
54	7.04	4.61	85.79	2.60	7.08	4.56	57.98	1.72
55	8.47	5.93	86.00	2.60	8.45	5.81	57.99	1.71
56	10.07	7.18	85.49	2.58	10.02	6.95	57.92	1.71
57	8.44	9.34	94.87	2.95	8.41	9.14	59.22	1.76
58	10.16	11.50	90.92	2.78	10.11	11.13	58.61	1.74
59	11.56	12.76	87.04	2.63	11.52	12.32	58.10	1.72
60	6.65	5.26	98.80	3.13	6.72	5.09	60.11	1.80
61	8.42	12.58	114.39	3.84	8.40	12.31	62.71	1.90
62	10.26	15.76	104.13	3.34	10.21	15.26	60.53	1.81
63	6.77	11.23	122.46	6.08	6.81	11.41	64.93	2.79
64	8.50	15.87	114.55	8.34	8.48	16.28	60.90	3.97
65	5.89	0.86	157.94	8.60	5.91	0.83	155.62	8.05
66	7.32	3.26	159.20	8.65	7.32	3.10	156.85	8.10
67	8.36	4.15	159.76	8.65	8.43	4.03	157.39	8.10
68	9.35	4.39	160.31	8.67	9.42	4.30	157.93	8.12
69	10.44	8.91	160.75	8.73	10.49	8.75	158.38	8.17
70	5.78	2.46	163.82	9.44	5.80	2.35	161.68	8.84
71	7.28	8.73	164.85	9.48	7.29	8.32	162.68	8.88
72	8.36	11.19	164.05	9.25	8.42	10.85	161.81	8.67
73	9.39	11.90	163.90	9.18	9.47	11.65	161.63	8.59
74	8.37	17.63	180.29	12.73	8.43	17.08	178.71	11.92
75	9.47	18.99	178.30	12.16	9.54	18.59	176.61	11.38
76	10.67	19.18	171.89	10.66	10.73	18.84	169.93	9.98
77	6.49	9.02	190.60	16.93	6.49	8.57	189.56	15.86
78	8.41	22.63	196.77	20.39	8.45	23.03	195.97	19.10
79	9.56	26.03	194.41	18.97	9.63	25.49	193.51	17.76
80	10.71	26.94	187.42	15.51	10.76	26.46	186.21	14.52
81	6.84	17.97	200.26	42.14	6.81	18.11	199.90	39.48
82	6.67	23.92	190.59	86.31	6.66	24.50	190.29	81.79
83	5.93	1.21	173.10	14.98	5.93	1.21	172.22	15.09
84	7.24	3.06	174.59	15.10	7.26	3.10	173.72	15.21
85	8.87	4.67	175.53	15.13	8.88	4.76	174.64	15.24
86	9.74	5.19	176.30	15.18	9.74	5.29	175.40	15.29
87	10.58	10.48	176.28	15.16	10.56	10.63	175.38	15.27
88	5.90	3.29	174.75	15.37	5.90	3.28	173.91	15.49
89	7.30	8.43	176.32	15.53	7.33	8.55	175.47	15.65
90	8.87	12.76	177.34	15.60	8.89	13.01	176.49	15.73
91	9.76	14.13	177.32	15.43	9.75	14.38	176.44	15.55
92	8.90	20.22	184.89	18.75	8.91	20.62	184.31	18.92

93	9.84	22.73	182.57	17.37	9.83	23.15	181.84	17.51
94	10.80	22.70	178.94	15.98	10.77	23.04	178.11	16.11
95	6.16	9.23	185.44	20.35	6.16	9.28	184.96	20.54
96	8.93	27.52	194.56	26.97	8.95	28.07	194.23	27.19
97	9.92	31.51	190.93	22.71	9.91	32.10	190.51	22.92
98	10.83	32.20	184.98	18.65	10.80	32.69	184.33	18.80
99	6.58	18.22	190.71	41.43	6.60	18.36	190.49	41.75
100	6.52	23.48	172.98	74.48	6.53	23.62	172.77	74.99
101	5.98	19.46	139.72	73.35	5.98	19.53	139.66	74.18
102	5.86	15.03	114.01	63.97	5.86	15.08	113.51	64.24
103	5.93	0.77	161.19	8.47	5.90	0.81	162.68	9.33
104	7.37	2.77	162.54	8.52	7.37	2.97	164.04	9.38
105	8.65	3.85	163.16	8.53	8.59	4.06	164.68	9.39
106	9.63	4.23	163.77	8.54	9.55	4.40	165.30	9.41
107	10.61	8.61	164.00	8.57	10.52	8.91	165.53	9.45
108	5.84	2.17	165.58	9.02	5.81	2.31	166.99	9.94
109	7.35	7.47	166.67	9.06	7.35	8.00	168.09	9.99
110	8.63	10.38	166.29	8.93	8.58	10.95	167.75	9.83
111	9.66	11.44	166.34	8.88	9.58	11.92	167.82	9.79
112	8.64	16.36	180.34	11.40	8.59	17.27	181.46	12.55
113	9.73	18.26	178.59	11.02	9.65	19.04	179.77	12.14
114	10.82	18.51	172.69	9.92	10.73	19.13	174.01	10.93
115	6.45	7.61	189.41	14.36	6.45	8.11	190.22	15.80
116	8.66	22.09	195.57	17.04	8.61	23.32	196.20	18.74
117	6.80	16.12	197.82	33.46	6.80	17.21	198.22	37.11
118	8.79	30.81	192.40	35.57	8.78	31.06	192.99	38.94
119	6.65	21.98	186.51	69.58	6.64	23.37	186.79	75.46
120	5.99	18.56	158.78	74.90	5.95	20.02	159.16	79.73
121	9.05	45.37	151.02	58.61	8.99	48.19	151.85	62.23
122	5.74	18.21	131.97	70.13	5.70	17.90	131.03	70.06
123	6.40	0.42	78.36	2.83	6.48	0.41	57.17	2.01
124	7.23	1.71	78.76	2.84	7.25	1.70	57.21	2.00
125	8.59	2.26	78.89	2.84	8.66	2.30	57.22	2.00
126	9.85	2.56	79.02	2.85	9.92	2.64	57.23	2.00
127	11.24	5.62	79.10	2.85	11.27	5.82	57.26	2.00
128	6.36	1.19	79.90	2.90	6.45	1.15	57.46	2.02
129	7.11	4.54	80.40	2.91	7.14	4.52	57.53	2.02
130	8.49	5.83	80.51	2.91	8.59	5.98	57.51	2.01
131	10.00	6.90	79.98	2.88	10.08	7.15	57.41	2.01
132	8.44	9.11	88.74	3.28	8.55	9.35	58.91	2.07
133	10.10	11.04	84.96	3.11	10.17	11.43	58.18	2.04
134	6.72	5.01	92.77	3.50	6.75	4.94	60.02	2.13
135	8.44	12.23	107.84	4.29	8.54	12.56	63.06	2.26
136	6.82	11.18	118.91	7.08	6.84	11.12	68.05	3.46
137	8.55	16.17	112.58	10.02	8.64	16.64	64.85	5.04
138	6.74	17.97	113.39	15.98	6.75	17.32	68.35	8.12

	Line7				Line8			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.81	0.63	147.36	8.93	5.80	0.59	146.54	8.02
2	7.55	2.62	148.50	8.97	7.56	2.39	147.67	8.07
3	8.37	3.36	148.94	8.97	8.44	3.12	148.10	8.06
4	9.04	3.30	149.40	8.99	9.17	3.13	148.56	8.07
5	9.90	6.38	149.80	9.05	10.11	6.18	148.96	8.13
6	5.63	1.69	153.03	9.77	5.64	1.57	152.25	8.77
7	7.66	6.99	153.97	9.79	7.66	6.39	153.19	8.79
8	8.37	9.14	153.06	9.57	8.43	8.48	152.25	8.60
9	9.03	9.06	152.84	9.49	9.18	8.60	152.02	8.52
10	8.39	14.57	171.09	12.94	8.45	13.55	170.46	11.61
11	9.11	14.66	168.54	12.32	9.25	13.94	167.88	11.06
12	6.71	5.82	181.56	16.81	6.68	5.33	183.51	15.44
13	7.36	15.16	197.92	45.10	7.34	13.86	197.83	39.19
14	8.52	32.01	192.42	49.03	8.57	28.66	192.21	42.52
15	7.44	22.30	186.79	130.04	7.41	20.52	187.56	115.89
16	5.77	1.17	160.06	15.54	5.77	1.17	161.43	15.32
17	7.52	3.40	161.38	15.64	7.47	3.31	162.76	15.42
18	8.80	5.19	162.00	15.63	8.76	4.99	163.41	15.43
19	9.25	5.20	162.42	15.65	9.23	4.99	163.84	15.45
20	5.78	3.21	168.24	17.91	5.78	3.21	169.54	17.60
21	7.48	9.43	169.37	17.95	7.43	9.19	170.69	17.65
22	8.65	13.64	169.26	17.71	8.61	13.12	170.60	17.40
23	8.65	21.26	179.50	22.66	8.60	20.47	180.92	22.40
24	6.25	9.16	179.99	25.14	6.24	9.11	181.24	24.83
25	8.67	28.37	190.59	34.13	8.63	27.32	191.46	33.73
26	6.81	20.77	187.71	67.09	6.78	20.50	188.33	66.25
27	8.87	45.33	184.73	95.08	8.84	43.58	185.76	94.29
28	7.02	25.28	169.75	222.33	6.98	24.97	170.39	219.08
29	6.38	13.83	136.90	541.38	6.37	13.78	137.25	529.26
30	5.80	0.69	165.63	11.30	5.82	0.72	169.20	12.14
31	7.61	2.85	167.02	11.37	7.57	3.01	170.63	12.22
32	8.40	3.72	167.68	11.37	8.31	3.82	171.33	12.22
33	8.96	3.61	168.31	11.40	8.86	3.65	171.99	12.24
34	9.66	6.77	168.55	11.46	9.55	6.80	172.20	12.31
35	5.62	1.83	169.18	12.14	5.63	1.91	169.47	12.78
36	7.72	7.73	170.86	12.23	7.68	8.12	171.19	12.87
37	8.38	10.18	170.67	12.01	8.30	10.43	171.77	12.72
38	8.92	9.88	170.77	11.93	8.82	10.00	172.74	12.70
39	8.39	16.18	179.16	15.03	8.32	16.57	179.14	14.01
40	8.98	15.92	179.19	14.68	8.89	16.12	179.28	14.76
41	9.83	14.71	175.79	13.35	9.74	14.81	176.04	14.04
42	6.71	6.23	186.87	16.13	6.66	7.03	190.94	17.67
43	8.41	21.85	194.64	19.49	8.33	23.29	198.00	21.84
44	9.06	21.82	190.89	17.82	8.96	22.09	194.36	19.48
45	7.37	17.20	199.39	52.93	7.37	18.21	200.02	58.49

46	8.52	35.54	195.30	59.36	8.47	36.19	196.47	65.69
47	7.52	23.86	188.01	173.39	7.50	25.07	188.49	200.48
48	6.49	0.42	59.72	1.78	6.42	0.42	87.13	2.71
49	7.21	1.70	59.87	1.78	7.21	1.72	87.79	2.72
50	8.50	2.21	59.87	1.78	8.46	2.20	87.97	2.72
51	9.80	2.49	59.92	1.78	9.73	2.45	88.20	2.73
52	11.24	5.54	59.96	1.78	11.17	5.38	88.29	2.73
53	6.46	1.17	60.23	1.80	6.39	1.20	89.19	2.78
54	7.10	4.56	60.40	1.80	7.10	4.60	89.92	2.80
55	8.41	5.75	60.52	1.80	8.35	5.71	90.31	2.81
56	9.94	6.77	60.34	1.79	9.85	6.61	89.62	2.78
57	8.37	9.03	64.03	1.92	8.30	8.96	101.79	3.29
58	10.03	10.85	62.66	1.87	9.94	10.61	97.21	3.09
59	11.46	11.96	61.07	1.82	11.39	11.65	91.99	2.87
60	6.75	5.04	64.94	1.96	6.73	5.08	105.29	3.47
61	8.35	12.16	73.65	2.28	8.29	12.07	125.35	4.51
62	10.14	14.89	69.23	2.11	10.05	14.58	114.58	3.90
63	6.83	11.33	78.04	3.47	6.83	11.38	132.99	7.29
64	8.46	16.19	79.00	5.43	8.42	16.16	130.38	10.89
65	5.94	0.78	155.00	7.41	5.96	0.74	154.26	6.71
66	7.32	2.92	156.22	7.46	7.31	2.72	155.48	6.75
67	8.47	3.84	156.75	7.46	8.52	3.62	156.00	6.76
68	9.49	4.13	157.28	7.47	9.57	3.95	156.53	6.77
69	10.58	8.48	157.74	7.52	10.68	8.18	156.99	6.81
70	5.83	2.23	161.10	8.14	5.87	2.09	160.42	7.38
71	7.29	7.83	162.10	8.18	7.27	7.29	161.41	7.40
72	8.46	10.31	161.21	7.98	8.51	9.72	160.50	7.23
73	9.54	11.20	161.01	7.91	9.62	10.71	160.29	7.17
74	8.46	16.23	178.28	10.98	8.51	15.31	177.78	9.96
75	9.62	17.87	176.16	10.48	9.70	17.09	175.62	9.50
76	10.82	18.26	169.40	9.19	10.92	17.64	168.77	8.32
77	6.50	8.10	189.28	14.62	6.50	7.60	188.95	13.26
78	8.48	21.88	195.77	17.61	8.53	20.63	195.52	15.98
79	9.70	24.51	193.28	16.37	9.79	23.45	193.00	14.84
80	10.85	25.65	185.89	13.38	10.95	24.77	185.50	12.12
81	6.81	17.11	199.74	36.14	6.80	16.02	199.55	32.57
82	6.66	23.24	190.20	76.33	6.66	21.87	190.11	70.11
83	5.93	1.22	173.32	15.07	5.93	1.21	174.97	14.93
84	7.23	3.07	174.82	15.18	7.19	3.00	176.49	15.04
85	8.86	4.68	175.76	15.22	8.83	4.53	177.45	15.08
86	9.73	5.20	176.53	15.27	9.74	5.04	178.23	15.13
87	10.58	10.50	176.51	15.24	10.61	10.25	178.21	15.11
88	5.90	3.32	174.99	15.47	5.90	3.30	176.61	15.32
89	7.30	8.46	176.55	15.62	7.25	8.28	178.19	15.47
90	8.86	12.79	177.58	15.70	8.83	12.39	179.22	15.55
91	9.75	14.15	177.55	15.53	9.76	13.74	179.23	15.38
92	8.89	20.27	185.17	18.88	8.86	19.63	186.39	18.69

93	9.83	22.77	182.82	17.48	9.84	22.09	184.27	17.32
94	10.80	22.75	179.19	16.09	10.84	22.22	180.80	15.94
95	6.16	9.28	185.70	20.51	6.15	9.25	186.73	20.29
96	8.93	27.58	194.73	27.16	8.89	26.69	195.44	26.92
97	9.91	31.56	191.17	22.89	9.92	30.60	192.09	22.66
98	10.82	32.26	185.21	18.77	10.87	31.48	186.52	18.61
99	6.58	18.30	190.83	41.69	6.55	18.11	191.31	41.33
100	6.51	23.57	173.03	74.84	6.49	23.39	173.41	74.22
101	5.98	19.55	139.82	73.91	5.97	19.49	139.82	72.84
102	5.85	15.11	113.62	63.96	5.85	15.07	113.90	63.50
103	5.88	0.84	165.69	10.09	5.85	0.87	169.24	10.75
104	7.36	3.13	167.08	10.15	7.34	3.26	170.67	10.82
105	8.52	4.18	167.75	10.15	8.43	4.26	171.38	10.82
106	9.48	4.49	168.40	10.18	9.40	4.53	172.05	10.85
107	10.46	9.06	168.61	10.21	10.41	9.13	172.25	10.88
108	5.77	2.42	169.83	10.74	5.75	2.51	173.16	11.44
109	7.34	8.43	170.95	10.79	7.31	8.80	174.31	11.49
110	8.51	11.31	170.69	10.63	8.43	11.52	174.15	11.32
111	9.50	12.17	170.80	10.58	9.43	12.28	174.31	11.27
112	8.52	17.83	183.72	13.56	8.44	18.17	186.32	14.45
113	9.57	19.44	182.13	13.11	9.50	19.61	184.85	13.97
114	10.67	19.46	176.66	11.81	10.63	19.62	179.75	12.58
115	6.51	8.13	191.83	17.06	6.51	8.54	193.60	18.14
116	8.56	22.94	197.44	20.23	8.48	23.37	198.74	21.46
117	6.83	17.17	198.82	39.96	6.82	18.02	199.48	42.42
118	8.72	32.03	194.14	41.86	8.65	32.51	195.43	44.37
119	6.66	22.94	187.31	80.33	6.65	24.05	187.80	83.99
120	5.94	19.35	159.85	83.21	5.93	20.24	160.60	85.65
121	9.03	47.51	153.35	64.78	8.94	47.88	155.01	66.50
122	5.66	19.12	133.19	73.81	5.64	17.89	134.21	76.89
123	6.46	0.43	57.98	2.01	6.36	0.47	79.97	2.81
124	7.25	1.71	58.09	2.01	7.22	1.74	80.51	2.83
125	8.71	2.36	58.14	2.00	8.72	2.40	80.73	2.82
126	9.98	2.74	58.18	2.00	10.01	2.81	80.91	2.83
127	11.28	6.04	58.16	2.00	11.29	6.25	80.90	2.83
128	6.44	1.19	58.22	2.01	6.35	1.31	81.43	2.86
129	7.15	4.56	58.34	2.01	7.12	4.63	82.03	2.88
130	8.66	6.17	58.45	2.01	8.68	6.34	82.38	2.89
131	10.13	7.44	58.37	2.01	10.15	7.69	81.89	2.87
132	8.62	9.66	60.46	2.09	8.65	9.97	91.30	3.28
133	10.22	11.88	59.73	2.06	10.23	12.30	87.73	3.11
134	6.73	4.98	60.73	2.11	6.67	5.14	93.88	3.42
135	8.61	12.99	66.22	2.34	8.64	13.41	111.43	4.31
136	6.83	11.20	66.77	3.32	6.80	11.05	117.03	6.59
137	8.70	17.30	66.63	5.09	8.73	17.16	113.22	9.63
138	6.73	17.68	61.47	7.04	6.70	17.54	103.54	13.26

	Line9				Line10			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.96	0.74	146.70	7.38	5.93	0.78	147.45	8.14
2	7.31	2.72	147.84	7.42	7.32	2.91	148.59	8.19
3	8.52	3.62	148.29	7.42	8.47	3.83	149.05	8.19
4	9.57	3.95	148.75	7.43	9.49	4.13	149.51	8.20
5	10.68	8.17	149.14	7.47	10.58	8.47	149.90	8.24
6	5.86	2.10	152.31	7.97	5.82	2.23	153.02	8.80
7	7.27	7.28	153.26	8.01	7.28	7.82	153.98	8.83
8	8.51	9.71	152.36	7.85	8.46	10.29	153.10	8.66
9	9.62	10.70	152.16	7.79	9.54	11.19	152.90	8.60
10	8.51	15.29	170.41	10.42	8.46	16.22	170.99	11.49
11	9.70	17.09	167.87	9.98	9.61	17.86	168.48	11.01
12	6.50	7.60	183.40	13.61	6.49	8.11	183.81	15.00
13	6.80	16.02	196.76	32.68	6.80	17.11	197.09	36.38
14	8.68	28.25	190.38	34.20	8.64	30.08	190.79	37.83
15	6.66	21.90	186.88	69.53	6.66	23.27	187.02	75.62
16	6.42	0.42	80.32	2.85	6.49	0.42	58.00	2.00
17	7.21	1.72	80.83	2.87	7.21	1.70	58.10	2.00
18	8.47	2.20	81.01	2.87	8.50	2.21	58.13	2.00
19	9.73	2.45	81.17	2.87	9.80	2.49	58.15	2.00
20	6.39	1.19	82.13	2.93	6.46	1.17	58.43	2.01
21	7.11	4.60	82.75	2.94	7.11	4.56	58.56	2.01
22	8.35	5.71	83.01	2.95	8.41	5.76	58.62	2.01
23	8.31	8.97	93.04	3.40	8.37	9.04	61.35	2.12
24	6.73	5.07	96.65	3.60	6.75	5.03	62.36	2.17
25	8.30	12.09	115.08	4.58	8.36	12.17	69.08	2.45
26	6.83	11.35	124.56	7.42	6.83	11.31	73.97	3.72
27	8.43	16.23	120.72	10.84	8.47	16.25	73.10	5.60
28	6.75	18.25	116.91	16.65	6.75	17.65	73.83	8.62
29	6.61	14.35	84.97	19.56	6.65	13.89	63.75	14.01
30	5.82	0.72	169.19	12.14	5.80	0.69	165.64	11.30
31	7.57	3.01	170.62	12.22	7.61	2.85	167.04	11.37
32	8.31	3.82	171.32	12.22	8.40	3.72	167.70	11.37
33	8.86	3.65	171.99	12.24	8.96	3.61	168.33	11.40
34	9.55	6.80	172.19	12.31	9.66	6.77	168.55	11.46
35	5.63	1.92	169.46	12.77	5.62	1.83	169.18	12.14
36	7.68	8.12	171.19	12.87	7.72	7.73	170.87	12.22
37	8.31	10.44	171.77	12.72	8.38	10.18	170.68	12.01
38	8.82	10.00	172.74	12.70	8.92	9.89	170.78	11.93
39	8.32	16.58	179.14	14.01	8.39	16.18	179.17	15.02
40	8.89	16.12	179.28	14.76	8.98	15.93	179.20	14.68
41	9.74	14.82	176.04	14.04	9.83	14.72	175.80	13.34
42	6.66	7.03	190.91	17.67	6.71	6.23	186.87	16.12
43	8.33	23.30	197.98	21.83	8.41	21.86	194.65	19.49
44	8.96	22.10	194.34	19.48	9.06	21.83	190.90	17.81
45	7.37	18.21	199.99	58.47	7.37	17.21	199.40	52.92

46	8.47	36.21	196.44	65.68	8.53	35.55	195.30	59.34
47	7.50	25.07	188.45	200.44	7.52	23.86	188.00	173.33
48	5.77	1.18	171.28	14.75	5.77	1.19	170.22	14.96
49	7.45	3.30	172.72	14.86	7.51	3.39	171.65	15.07
50	8.75	4.96	173.49	14.87	8.80	5.18	172.42	15.08
51	9.23	4.97	174.01	14.89	9.25	5.19	172.92	15.11
52	9.55	8.69	174.95	14.99	9.55	9.05	173.87	15.20
53	5.77	3.23	178.96	16.70	5.78	3.24	177.96	17.03
54	7.41	9.19	180.14	16.74	7.46	9.43	179.14	17.08
55	8.60	13.10	180.21	16.51	8.64	13.62	179.19	16.85
56	9.08	12.96	178.64	15.83	9.11	13.51	177.58	16.16
57	8.60	20.46	189.68	21.81	8.64	21.25	188.54	22.08
58	9.11	20.46	187.88	19.71	9.14	21.31	186.58	19.96
59	9.66	18.22	182.59	17.22	9.65	18.93	181.60	17.55
60	6.23	9.16	189.04	24.27	6.24	9.20	188.05	24.58
61	8.62	27.31	196.80	33.20	8.67	28.37	196.15	33.62
62	9.18	27.73	194.28	26.99	9.20	28.87	193.42	27.32
63	6.77	20.58	192.11	65.39	6.80	20.84	191.67	66.25
64	8.83	43.55	190.96	94.21	8.86	45.32	190.17	94.92
65	5.79	0.59	153.99	7.25	5.80	0.64	154.79	8.07
66	7.55	2.39	155.19	7.29	7.55	2.62	156.01	8.11
67	8.43	3.12	155.70	7.29	8.37	3.35	156.52	8.11
68	9.17	3.12	156.21	7.30	9.04	3.29	157.04	8.13
69	10.11	6.18	156.69	7.37	9.90	6.37	157.52	8.20
70	5.63	1.58	160.25	8.06	5.63	1.70	161.00	8.97
71	7.66	6.38	161.23	8.08	7.66	6.98	161.98	8.99
72	8.43	8.47	160.28	7.87	8.37	9.13	161.06	8.76
73	9.18	8.59	160.04	7.79	9.04	9.05	160.84	8.67
74	8.45	13.53	177.74	11.02	8.39	14.55	178.28	12.28
75	9.25	13.93	175.55	10.46	9.11	14.65	176.13	11.65
76	10.29	13.51	168.64	9.10	10.09	13.93	169.32	10.14
77	6.67	5.34	188.98	14.94	6.70	5.83	188.58	16.51
78	8.46	18.37	195.56	18.12	8.41	19.72	194.28	19.70
79	9.33	19.18	193.01	16.65	9.19	20.15	193.31	18.57
80	10.35	19.14	185.49	13.45	10.15	19.75	185.90	14.99
81	7.33	13.86	200.32	38.44	7.35	15.16	200.38	44.20
82	7.40	20.55	190.57	116.35	7.43	22.35	190.43	130.64
83	6.36	0.47	86.41	2.56	6.47	0.43	58.83	1.70
84	7.22	1.74	87.04	2.57	7.26	1.72	58.95	1.70
85	8.73	2.41	87.33	2.57	8.72	2.36	59.02	1.70
86	10.01	2.82	87.55	2.58	9.97	2.74	59.05	1.70
87	11.29	6.26	87.63	2.58	11.28	6.05	59.08	1.70
88	6.35	1.30	88.36	2.62	6.44	1.19	59.23	1.71
89	7.13	4.64	89.12	2.63	7.15	4.57	59.40	1.71
90	8.69	6.36	89.48	2.64	8.66	6.19	59.50	1.71
91	10.15	7.71	88.91	2.62	10.12	7.46	59.39	1.71
92	8.65	10.00	100.50	3.07	8.63	9.70	62.32	1.81

93	10.23	12.32	96.30	2.89	10.21	11.90	61.39	1.77
94	11.49	13.44	91.28	2.70	11.49	13.00	60.09	1.73
95	6.67	5.14	103.97	3.23	6.73	4.98	63.06	1.84
96	8.65	13.46	123.23	4.14	8.62	13.03	69.94	2.08
97	10.32	16.87	113.14	3.62	10.31	16.30	66.92	1.96
98	11.53	18.78	101.15	3.09	11.53	18.19	63.09	1.83
99	6.81	11.07	129.86	6.42	6.83	11.23	71.76	3.00
100	6.71	17.56	116.44	12.84	6.74	17.74	65.80	6.21
101	6.57	14.24	83.83	16.05	6.64	13.52	55.99	9.86
102	6.53	12.75	64.97	18.20	6.58	12.53	52.18	13.96
103	5.85	0.87	169.26	10.74	5.88	0.84	165.68	10.08
104	7.34	3.26	170.70	10.81	7.36	3.13	167.09	10.14
105	8.43	4.26	171.41	10.82	8.52	4.18	167.76	10.15
106	9.40	4.53	172.07	10.85	9.48	4.49	168.39	10.17
107	10.41	9.13	172.27	10.88	10.46	9.06	168.61	10.21
108	5.75	2.51	173.18	11.43	5.77	2.42	169.83	10.73
109	7.31	8.80	174.34	11.49	7.34	8.43	170.95	10.79
110	8.43	11.52	174.18	11.32	8.51	11.31	170.69	10.62
111	9.43	12.29	174.33	11.27	9.50	12.18	170.80	10.57
112	8.44	18.17	186.34	14.44	8.52	17.83	183.71	13.56
113	9.50	19.61	184.88	13.97	9.57	19.44	182.12	13.11
114	10.63	19.62	179.78	12.58	10.67	19.46	176.66	11.81
115	6.51	8.55	193.64	18.14	6.51	8.13	191.82	17.06
116	8.48	23.37	198.77	21.45	8.56	22.94	197.43	20.23
117	6.83	18.02	199.52	42.41	6.83	17.18	198.80	39.95
118	8.65	32.51	195.45	44.35	8.72	32.04	194.12	41.84
119	6.65	24.05	187.81	83.95	6.66	22.95	187.25	80.30
120	5.93	20.25	160.56	85.52	5.94	19.35	159.69	83.10
121	8.95	47.96	154.91	66.30	9.03	47.60	153.08	64.59
122	5.64	17.89	133.99	76.61	5.66	19.13	132.76	73.59
123	5.93	1.22	163.75	15.36	5.93	1.22	161.92	15.50
124	7.18	3.01	165.17	15.48	7.22	3.07	163.32	15.62
125	8.82	4.52	166.00	15.51	8.86	4.67	164.13	15.65
126	9.73	5.04	166.68	15.56	9.73	5.20	164.79	15.70
127	10.61	10.24	166.66	15.53	10.57	10.49	164.77	15.67
128	5.90	3.32	165.55	15.74	5.90	3.33	163.76	15.89
129	7.25	8.29	167.08	15.90	7.29	8.47	165.27	16.04
130	8.83	12.38	168.03	15.98	8.86	12.79	166.20	16.12
131	9.75	13.73	167.84	15.81	9.75	14.14	165.97	15.95
132	8.86	19.63	177.05	19.06	8.89	20.27	175.61	19.25
133	9.83	22.08	173.95	17.67	9.83	22.76	172.28	17.83
134	6.15	9.27	178.42	20.59	6.16	9.31	177.18	20.79
135	8.89	26.69	189.62	27.08	8.93	27.58	188.72	27.32
136	6.55	18.13	187.19	41.42	6.60	17.24	186.59	41.78
137	9.04	37.50	185.33	56.91	9.06	38.94	184.66	57.38
138	6.49	23.44	169.35	73.98	6.51	23.61	168.93	74.61

	Line11				Line12			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.90	0.83	148.08	8.84	5.88	0.86	150.43	9.44
2	7.32	3.09	149.23	8.89	7.31	3.25	151.61	9.49
3	8.43	4.02	149.69	8.89	8.36	4.14	152.10	9.49
4	9.43	4.30	150.17	8.91	9.36	4.38	152.59	9.51
5	10.49	8.74	150.55	8.95	10.43	8.89	152.96	9.56
6	5.79	2.36	153.63	9.55	5.76	2.47	155.87	10.19
7	7.29	8.31	154.59	9.59	7.28	8.72	156.85	10.23
8	8.42	10.83	153.72	9.40	8.36	11.18	156.04	10.03
9	9.47	11.64	153.54	9.33	9.39	11.89	155.89	9.96
10	8.43	17.07	171.48	12.47	8.37	17.61	173.30	13.31
11	9.54	18.58	168.99	11.95	9.47	18.98	170.90	12.76
12	6.48	8.58	184.17	16.26	6.54	8.56	185.47	17.35
13	6.80	18.11	197.25	39.61	6.83	17.98	197.74	42.16
14	8.64	30.21	191.07	40.84	8.59	31.14	192.03	43.42
15	6.65	24.53	187.14	80.96	6.66	23.97	187.56	85.34
16	6.46	0.44	57.40	1.97	6.35	0.48	79.02	2.76
17	7.19	1.71	57.46	1.97	7.14	1.72	79.46	2.77
18	8.52	2.22	57.48	1.97	8.52	2.24	79.63	2.77
19	9.87	2.54	57.51	1.97	9.92	2.61	79.79	2.78
20	6.44	1.22	57.55	1.98	6.34	1.34	80.25	2.81
21	7.08	4.55	57.63	1.98	7.04	4.61	80.78	2.82
22	8.45	5.82	57.65	1.97	8.47	5.93	80.98	2.82
23	8.41	9.14	58.64	2.02	8.43	9.33	88.37	3.15
24	6.72	5.09	59.11	2.04	6.65	5.27	91.38	3.30
25	8.40	12.31	61.60	2.15	8.42	12.58	105.82	4.02
26	6.81	11.40	62.94	3.09	6.77	11.23	113.20	6.23
27	8.49	16.31	61.49	4.57	8.49	15.86	108.01	8.81
28	6.71	18.04	59.66	6.57	6.67	17.88	102.96	12.49
29	6.61	14.39	55.18	11.08	6.55	14.63	80.27	16.34
30	5.78	0.65	162.61	10.36	5.77	0.60	161.07	9.32
31	7.63	2.66	163.98	10.42	7.64	2.44	162.42	9.37
32	8.48	3.57	164.60	10.43	8.54	3.33	163.03	9.37
33	9.07	3.51	165.21	10.45	9.18	3.34	163.62	9.39
34	9.79	6.67	165.45	10.50	9.98	6.46	163.87	9.44
35	5.62	1.74	166.99	11.17	5.62	1.63	165.53	10.04
36	7.74	7.26	168.09	11.21	7.74	6.66	166.62	10.07
37	8.45	9.78	167.73	11.01	8.51	9.13	166.22	9.89
38	9.03	9.64	167.78	10.94	9.15	9.17	166.25	9.82
39	8.46	15.56	180.03	14.15	8.51	14.56	180.37	12.85
40	9.09	15.53	179.80	13.75	9.21	14.80	178.59	12.35
41	9.96	14.50	174.01	12.30	10.14	14.06	172.65	11.05
42	6.67	5.79	185.10	15.76	6.63	5.34	187.32	16.11
43	8.48	21.04	191.34	17.49	8.53	19.71	192.75	18.23
44	9.16	21.31	190.92	18.31	9.28	20.33	192.75	18.15
45	7.41	15.43	198.88	47.01	7.39	14.18	198.65	40.83

46	8.58	34.35	194.30	52.62	8.62	30.98	193.84	45.58
47	7.53	22.45	187.05	142.24	7.50	20.77	186.96	118.48
48	5.77	1.18	169.18	14.99	5.77	1.18	169.57	14.82
49	7.54	3.44	170.60	15.10	7.51	3.39	170.99	14.92
50	8.82	5.29	171.35	15.12	8.80	5.18	171.75	14.94
51	9.26	5.32	171.85	15.14	9.25	5.19	172.26	14.96
52	9.55	9.26	172.80	15.24	9.55	9.06	173.20	15.06
53	5.78	3.24	177.00	17.07	5.78	3.22	177.37	16.80
54	7.50	9.56	178.17	17.12	7.47	9.41	178.54	16.84
55	8.68	13.92	178.20	16.89	8.65	13.61	178.57	16.61
56	9.13	13.83	176.56	16.21	9.12	13.52	176.94	15.93
57	8.67	21.71	187.75	22.12	8.65	21.24	188.35	21.87
58	9.16	21.80	185.69	19.99	9.15	21.33	186.36	19.77
59	9.65	19.34	180.63	17.59	9.66	18.94	180.99	17.31
60	6.25	9.21	187.38	24.62	6.24	9.16	187.89	24.35
61	8.70	28.97	195.70	33.65	8.67	28.36	196.03	33.26
62	9.22	29.55	192.83	27.35	9.21	28.89	193.26	27.04
63	6.82	20.97	191.37	66.34	6.81	20.79	191.61	65.54
64	8.88	46.33	189.81	95.00	8.87	45.34	190.35	94.27
65	5.81	0.68	155.48	8.83	5.83	0.72	157.83	9.49
66	7.55	2.82	156.70	8.88	7.53	3.00	159.07	9.55
67	8.32	3.57	157.23	8.88	8.25	3.72	159.62	9.55
68	8.94	3.46	157.75	8.89	8.84	3.55	160.17	9.56
69	9.73	6.58	158.22	8.97	9.61	6.69	160.62	9.65
70	5.63	1.82	161.63	9.82	5.63	1.91	163.79	10.57
71	7.66	7.54	162.62	9.85	7.64	8.00	164.80	10.60
72	8.33	9.74	161.72	9.59	8.27	10.14	163.98	10.32
73	8.93	9.50	161.51	9.49	8.83	9.76	163.81	10.20
74	8.34	15.51	178.74	13.45	8.29	16.13	179.35	14.37
75	9.00	15.34	176.63	12.76	8.90	15.76	178.32	13.74
76	9.92	14.36	169.89	11.10	9.80	14.61	171.87	11.94
77	6.72	6.28	186.82	17.39	6.75	6.72	186.08	16.50
78	8.36	20.98	192.76	19.02	8.30	21.80	192.96	18.92
79	9.07	21.08	191.96	19.87	8.98	21.64	191.39	19.37
80	9.99	20.37	186.25	16.42	9.88	20.74	186.27	17.45
81	7.37	16.36	200.43	49.79	7.32	18.16	200.73	55.01
82	7.44	23.97	190.26	151.78	7.43	25.35	191.15	182.68
83	6.48	0.41	58.94	1.73	6.40	0.42	86.38	2.64
84	7.25	1.71	59.03	1.73	7.23	1.71	86.94	2.65
85	8.66	2.31	59.05	1.73	8.59	2.27	87.14	2.66
86	9.92	2.65	59.09	1.73	9.85	2.57	87.36	2.66
87	11.26	5.83	59.09	1.73	11.24	5.62	87.38	2.66
88	6.45	1.16	59.31	1.74	6.36	1.19	88.18	2.71
89	7.14	4.54	59.41	1.74	7.11	4.56	88.81	2.73
90	8.59	6.00	59.42	1.74	8.49	5.84	89.04	2.73
91	10.07	7.17	59.28	1.74	10.00	6.91	88.41	2.70
92	8.55	9.38	61.45	1.81	8.44	9.13	98.92	3.13

93	10.17	11.46	60.40	1.77	10.10	11.06	94.42	2.94
94	11.49	12.55	59.55	1.74	11.47	12.15	90.06	2.76
95	6.75	4.95	62.63	1.86	6.72	5.03	103.02	3.34
96	8.54	12.60	67.31	2.03	8.43	12.27	120.15	4.19
97	10.27	15.70	63.62	1.89	10.21	15.19	108.90	3.59
98	11.54	17.60	60.99	1.80	11.52	17.09	97.84	3.08
99	6.84	11.15	72.96	3.14	6.82	11.23	130.36	6.91
100	6.75	17.41	74.21	7.39	6.74	18.09	124.15	15.63
101	6.64	13.79	66.91	12.40	6.59	14.43	93.77	18.03
102	6.54	13.34	60.27	16.49	6.47	13.98	85.76	23.35
103	5.90	0.81	162.65	9.33	5.93	0.77	161.14	8.46
104	7.37	2.97	164.03	9.39	7.37	2.77	162.50	8.52
105	8.59	4.06	164.66	9.39	8.65	3.86	163.12	8.52
106	9.55	4.41	165.27	9.41	9.63	4.23	163.71	8.54
107	10.52	8.91	165.50	9.44	10.61	8.62	163.95	8.57
108	5.81	2.31	166.96	9.93	5.84	2.18	165.53	9.02
109	7.35	8.00	168.06	9.98	7.35	7.47	166.62	9.06
110	8.58	10.96	167.73	9.83	8.63	10.38	166.24	8.92
111	9.58	11.93	167.80	9.79	9.66	11.44	166.29	8.88
112	8.59	17.28	181.43	12.55	8.64	16.37	180.26	11.40
113	9.65	19.04	179.73	12.13	9.73	18.27	178.51	11.02
114	10.73	19.13	173.98	10.93	10.82	18.51	172.63	9.92
115	6.45	8.12	190.17	15.80	6.45	7.61	189.32	14.36
116	8.63	22.23	196.15	18.74	8.66	22.10	195.47	17.04
117	6.80	17.21	198.15	37.10	6.80	16.12	197.69	33.45
118	8.78	31.07	192.93	38.93	8.79	30.82	192.28	35.56
119	6.64	23.38	186.67	75.43	6.65	21.99	186.32	69.56
120	5.95	20.02	158.87	79.63	5.99	18.56	158.35	74.82
121	9.00	48.28	151.41	62.07	9.06	45.47	150.38	58.45
122	5.70	17.91	130.38	69.90	5.74	18.21	131.07	69.97
123	5.93	1.22	160.70	15.53	5.93	1.21	161.53	15.41
124	7.25	3.10	162.09	15.64	7.23	3.06	162.92	15.51
125	8.88	4.76	162.87	15.68	8.86	4.67	163.71	15.55
126	9.73	5.28	163.52	15.72	9.74	5.19	164.37	15.59
127	10.55	10.63	163.50	15.70	10.57	10.47	164.34	15.57
128	5.90	3.32	162.55	15.92	5.90	3.30	163.35	15.78
129	7.33	8.56	164.06	16.07	7.30	8.44	164.87	15.94
130	8.88	13.01	164.97	16.15	8.87	12.76	165.79	16.01
131	9.75	14.38	164.72	15.98	9.75	14.12	165.55	15.85
132	8.91	20.62	174.58	19.27	8.89	20.23	175.17	19.08
133	9.83	23.14	171.15	17.85	9.83	22.72	171.88	17.71
134	6.16	9.29	176.28	20.82	6.16	9.25	176.79	20.64
135	8.95	28.07	188.09	27.35	8.93	27.52	188.48	27.13
136	6.62	17.30	186.18	41.85	6.58	18.23	186.47	41.54
137	9.08	39.74	184.21	57.47	9.07	38.85	184.55	57.04
138	6.53	23.65	168.67	74.80	6.51	23.49	168.99	74.35

	Line13				Line14			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.88	0.86	150.42	9.43	5.90	0.83	148.05	8.84
2	7.31	3.25	151.60	9.49	7.32	3.10	149.20	8.89
3	8.36	4.14	152.09	9.49	8.43	4.02	149.66	8.89
4	9.35	4.39	152.58	9.51	9.43	4.30	150.14	8.91
5	10.43	8.89	152.95	9.56	10.49	8.74	150.52	8.95
6	5.77	2.47	155.86	10.19	5.79	2.36	153.59	9.54
7	7.28	8.72	156.85	10.23	7.29	8.31	154.56	9.58
8	8.36	11.18	156.03	10.03	8.42	10.84	153.69	9.39
9	9.39	11.89	155.88	9.96	9.47	11.64	153.50	9.33
10	8.37	17.62	173.32	13.31	8.43	17.07	171.47	12.46
11	9.47	18.98	170.91	12.75	9.54	18.58	168.97	11.94
12	6.54	8.56	185.51	17.35	6.48	8.58	184.17	16.26
13	6.83	17.98	197.81	42.14	6.80	18.12	197.28	39.59
14	8.59	31.15	192.06	43.40	8.64	30.22	191.06	40.83
15	6.66	23.98	187.60	85.28	6.65	24.53	187.12	80.90
16	5.93	1.21	161.67	15.41	5.93	1.22	160.76	15.53
17	7.23	3.06	163.06	15.53	7.25	3.10	162.15	15.64
18	8.86	4.66	163.86	15.56	8.88	4.76	162.93	15.68
19	9.74	5.19	164.52	15.61	9.73	5.28	163.58	15.72
20	5.90	3.31	163.49	15.80	5.90	3.32	162.61	15.92
21	7.30	8.44	165.00	15.95	7.32	8.56	164.12	16.07
22	8.86	12.76	165.92	16.03	8.88	13.01	165.02	16.15
23	8.89	20.23	175.32	19.11	8.91	20.62	174.66	19.28
24	6.16	9.26	176.92	20.65	6.16	9.30	176.36	20.83
25	8.93	27.52	188.54	27.14	8.95	28.07	188.13	27.36
26	6.58	18.24	186.46	41.53	6.62	17.30	186.17	41.84
27	9.06	38.84	184.51	57.03	9.08	39.74	184.18	57.46
28	6.51	23.50	168.88	74.25	6.53	23.65	168.61	74.73
29	5.98	19.47	135.42	73.48	5.98	19.53	135.27	74.21
30	5.93	0.77	161.19	8.47	5.90	0.81	162.68	9.33
31	7.37	2.77	162.54	8.52	7.37	2.97	164.05	9.38
32	8.65	3.85	163.16	8.53	8.59	4.06	164.68	9.39
33	9.63	4.23	163.76	8.54	9.55	4.40	165.30	9.41
34	10.61	8.61	164.00	8.57	10.52	8.91	165.53	9.45
35	5.84	2.17	165.58	9.02	5.81	2.31	167.00	9.94
36	7.35	7.47	166.67	9.06	7.35	8.00	168.10	9.99
37	8.63	10.38	166.29	8.93	8.58	10.95	167.75	9.83
38	9.66	11.44	166.34	8.88	9.58	11.92	167.82	9.79
39	8.64	16.37	180.32	11.40	8.59	17.27	181.46	12.55
40	9.73	18.26	178.58	11.02	9.65	19.04	179.76	12.14
41	10.82	18.51	172.69	9.92	10.73	19.13	174.01	10.93
42	6.45	7.61	189.40	14.36	6.45	8.11	190.21	15.80
43	8.66	22.09	195.56	17.04	8.61	23.32	196.20	18.74
44	9.81	25.07	193.81	16.10	9.73	26.13	194.51	17.72
45	6.80	16.12	197.81	33.46	6.80	17.21	198.21	37.11

46	8.79	30.81	192.38	35.57	8.78	31.06	192.99	38.94
47	6.65	21.98	186.47	69.58	6.64	23.37	186.77	75.46
48	6.40	0.42	84.19	2.61	6.48	0.41	58.11	1.73
49	7.23	1.71	84.67	2.61	7.25	1.70	58.17	1.73
50	8.59	2.26	84.92	2.62	8.66	2.30	58.21	1.73
51	9.85	2.56	85.07	2.62	9.92	2.64	58.22	1.73
52	11.24	5.62	85.10	2.62	11.27	5.82	58.23	1.73
53	6.36	1.19	86.10	2.68	6.45	1.15	58.51	1.75
54	7.11	4.54	86.66	2.69	7.14	4.52	58.58	1.74
55	8.49	5.83	86.80	2.69	8.59	5.98	58.55	1.74
56	10.00	6.90	86.15	2.66	10.08	7.15	58.41	1.74
57	8.44	9.11	96.71	3.10	8.55	9.35	60.45	1.81
58	10.10	11.04	92.24	2.90	10.17	11.43	59.48	1.77
59	11.47	12.13	87.90	2.73	11.49	12.53	58.70	1.74
60	6.72	5.01	101.38	3.32	6.75	4.94	61.91	1.87
61	8.44	12.23	118.11	4.14	8.54	12.56	65.87	2.02
62	10.22	15.16	106.84	3.55	10.28	15.67	62.45	1.89
63	6.82	11.18	129.27	6.91	6.84	11.11	72.15	3.17
64	8.55	16.17	122.93	9.75	8.64	16.64	68.20	4.56
65	5.83	0.72	157.91	9.50	5.81	0.68	155.55	8.83
66	7.53	3.00	159.16	9.55	7.55	2.82	156.78	8.88
67	8.25	3.72	159.71	9.55	8.32	3.57	157.30	8.88
68	8.84	3.55	160.25	9.57	8.93	3.46	157.83	8.89
69	9.61	6.69	160.71	9.65	9.73	6.58	158.29	8.97
70	5.63	1.91	163.88	10.57	5.62	1.82	161.70	9.82
71	7.64	8.00	164.89	10.60	7.66	7.55	162.69	9.85
72	8.27	10.14	164.07	10.32	8.33	9.74	161.80	9.59
73	8.83	9.76	163.90	10.20	8.93	9.50	161.59	9.49
74	8.28	16.13	179.43	14.36	8.34	15.51	178.82	13.46
75	8.90	15.76	178.42	13.75	8.99	15.35	176.70	12.76
76	9.80	14.62	171.96	11.95	9.92	14.36	169.97	11.10
77	6.75	6.72	186.17	16.49	6.72	6.28	186.90	17.39
78	8.30	21.81	193.07	18.92	8.36	20.99	192.83	19.01
79	8.98	21.64	191.48	19.36	9.07	21.09	192.04	19.87
80	9.88	20.75	186.36	17.45	9.99	20.37	186.33	16.43
81	7.33	18.16	200.85	55.03	7.37	16.37	200.51	49.80
82	7.43	25.37	191.33	182.77	7.44	23.98	190.41	151.89
83	5.77	1.17	168.94	14.78	5.77	1.17	168.81	14.97
84	7.49	3.38	170.35	14.88	7.54	3.44	170.22	15.07
85	8.80	5.17	171.08	14.89	8.81	5.29	170.95	15.09
86	9.25	5.19	171.59	14.91	9.26	5.32	171.46	15.11
87	9.55	9.05	172.54	15.01	9.55	9.26	172.42	15.21
88	5.77	3.25	176.80	16.71	5.78	3.24	176.68	17.02
89	7.47	9.41	177.97	16.75	7.49	9.56	177.84	17.06
90	8.65	13.61	177.98	16.51	8.67	13.92	177.86	16.83
91	9.12	13.51	176.32	15.83	9.13	13.83	176.20	16.15
92	8.65	21.24	188.13	21.84	8.67	21.71	187.64	22.10

93	9.15	21.32	186.09	19.74	9.16	21.81	185.54	19.97
94	9.65	18.94	180.41	17.21	9.65	19.34	180.30	17.53
95	6.24	9.17	187.70	24.31	6.25	9.21	187.28	24.60
96	8.67	28.35	195.90	33.23	8.70	28.97	195.64	33.63
97	9.21	28.88	193.10	27.00	9.22	29.54	192.75	27.33
98	9.72	26.55	188.23	21.53	9.72	27.11	187.74	21.79
99	6.80	20.81	191.49	65.44	6.82	20.98	191.31	66.28
100	7.00	25.48	173.81	216.45	7.03	25.64	173.48	219.73
101	6.38	14.10	141.05	517.31	6.39	14.07	140.73	530.08
102	6.09	9.85	114.84	814.05	6.09	9.83	114.28	834.54
103	5.77	0.61	161.02	9.32	5.78	0.65	162.58	10.37
104	7.64	2.44	162.36	9.37	7.63	2.66	163.94	10.43
105	8.54	3.33	162.96	9.38	8.48	3.57	164.56	10.43
106	9.18	3.33	163.56	9.40	9.07	3.51	165.17	10.45
107	9.98	6.46	163.81	9.44	9.79	6.67	165.41	10.50
108	5.62	1.63	165.48	10.04	5.62	1.74	166.96	11.17
109	7.74	6.66	166.56	10.07	7.74	7.25	168.05	11.21
110	8.51	9.12	166.16	9.90	8.45	9.77	167.69	11.01
111	9.15	9.16	166.18	9.83	9.03	9.63	167.74	10.94
112	8.51	14.55	180.29	12.85	8.46	15.55	180.00	14.15
113	9.21	14.79	178.51	12.36	9.09	15.53	179.76	13.76
114	10.14	14.05	172.58	11.05	9.96	14.50	173.97	12.30
115	6.63	5.34	187.25	16.12	6.67	5.79	185.06	15.78
116	8.53	19.70	192.67	18.25	8.48	21.03	191.28	17.49
117	7.39	14.18	198.55	40.85	7.41	15.43	198.83	47.02
118	8.62	30.96	193.76	45.60	8.58	34.33	194.26	52.64
119	7.50	20.77	186.89	118.56	7.53	22.45	187.02	142.30
120	6.88	12.77	159.51	228.13	6.99	13.37	160.26	296.09
121	8.73	52.84	152.70	176.43	8.69	55.08	154.49	229.75
122	6.56	8.98	133.49	381.82	6.58	9.49	133.66	501.67
123	6.35	0.48	77.81	2.75	6.46	0.44	56.82	1.99
124	7.14	1.72	78.24	2.76	7.19	1.70	56.88	1.98
125	8.52	2.24	78.42	2.76	8.52	2.22	56.90	1.98
126	9.92	2.61	78.59	2.76	9.87	2.54	56.92	1.98
127	11.35	5.92	78.64	2.77	11.31	5.71	56.94	1.98
128	6.34	1.34	79.09	2.80	6.44	1.22	57.00	1.99
129	7.04	4.61	79.64	2.81	7.08	4.56	57.08	1.99
130	8.47	5.93	79.81	2.82	8.45	5.81	57.08	1.99
131	10.07	7.18	79.40	2.79	10.02	6.95	57.03	1.99
132	8.44	9.34	87.10	3.13	8.41	9.14	57.98	2.03
133	10.16	11.50	83.80	2.98	10.11	11.13	57.53	2.01
134	6.65	5.26	90.46	3.30	6.72	5.09	58.63	2.06
135	8.42	12.58	104.35	3.99	8.40	12.31	60.59	2.15
136	6.77	11.23	112.27	6.24	6.81	11.41	62.26	3.11
137	8.50	15.87	104.56	8.60	8.48	16.28	59.11	4.51
138	6.68	17.88	101.07	12.46	6.72	18.07	58.32	6.65

	Line15				Line16			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.93	0.78	147.39	8.14	5.96	0.74	146.62	7.38
2	7.32	2.92	148.53	8.19	7.31	2.72	147.76	7.42
3	8.47	3.83	148.99	8.19	8.52	3.62	148.20	7.42
4	9.49	4.13	149.47	8.20	9.57	3.95	148.67	7.43
5	10.58	8.47	149.85	8.24	10.68	8.17	149.06	7.47
6	5.82	2.23	152.97	8.79	5.86	2.10	152.22	7.97
7	7.28	7.82	153.93	8.83	7.27	7.28	153.18	8.00
8	8.46	10.30	153.04	8.65	8.51	9.71	152.27	7.85
9	9.54	11.19	152.85	8.60	9.62	10.70	152.07	7.79
10	8.46	16.22	170.95	11.49	8.51	15.30	170.32	10.42
11	9.61	17.87	168.42	11.01	9.70	17.09	167.77	9.98
12	6.49	8.11	183.78	14.99	6.50	7.60	183.31	13.61
13	6.80	17.11	197.07	36.36	6.80	16.03	196.67	32.66
14	8.64	30.09	190.75	37.81	8.68	28.26	190.27	34.19
15	6.66	23.28	186.93	75.57	6.66	21.91	186.70	69.48
16	5.93	1.22	161.90	15.50	5.93	1.22	163.63	15.35
17	7.22	3.07	163.30	15.61	7.18	3.01	165.05	15.46
18	8.86	4.67	164.10	15.65	8.83	4.52	165.87	15.50
19	9.73	5.20	164.76	15.69	9.73	5.04	166.54	15.54
20	5.90	3.33	163.74	15.89	5.90	3.31	165.45	15.73
21	7.29	8.47	165.26	16.04	7.25	8.29	166.99	15.88
22	8.86	12.79	166.18	16.12	8.83	12.39	167.92	15.96
23	8.89	20.27	175.63	19.25	8.86	19.63	177.00	19.04
24	6.16	9.31	177.20	20.79	6.15	9.27	178.39	20.59
25	8.93	27.59	188.74	27.32	8.89	26.70	189.62	27.08
26	6.60	17.24	186.59	41.78	6.55	18.13	187.20	41.42
27	9.06	38.95	184.65	57.37	9.04	37.52	185.33	56.89
28	6.51	23.59	168.91	74.58	6.49	23.41	169.38	73.99
29	5.97	19.56	135.46	73.96	5.97	19.49	135.51	72.96
30	5.88	0.84	165.69	10.08	5.85	0.87	169.25	10.75
31	7.36	3.13	167.09	10.15	7.34	3.26	170.68	10.81
32	8.52	4.18	167.76	10.15	8.43	4.26	171.39	10.82
33	9.48	4.49	168.40	10.18	9.40	4.53	172.06	10.85
34	10.46	9.06	168.62	10.21	10.41	9.13	172.26	10.88
35	5.77	2.42	169.84	10.74	5.75	2.51	173.17	11.44
36	7.34	8.43	170.96	10.79	7.31	8.80	174.32	11.49
37	8.51	11.31	170.70	10.63	8.43	11.52	174.16	11.32
38	9.50	12.17	170.81	10.58	9.43	12.28	174.32	11.27
39	8.52	17.83	183.72	13.56	8.44	18.17	186.32	14.45
40	9.57	19.44	182.13	13.11	9.50	19.61	184.86	13.97
41	10.67	19.46	176.67	11.81	10.63	19.62	179.76	12.58
42	6.51	8.13	191.83	17.06	6.51	8.54	193.61	18.14
43	8.56	22.94	197.44	20.23	8.48	23.37	198.75	21.46
44	9.66	26.67	195.90	19.14	9.65	25.96	197.47	20.39
45	6.83	17.17	198.82	39.96	6.83	18.02	199.49	42.42

46	8.72	32.03	194.14	41.86	8.65	32.51	195.44	44.37
47	6.66	22.94	187.30	80.33	6.65	24.05	187.80	83.99
48	6.46	0.43	59.20	1.74	6.36	0.47	86.17	2.60
49	7.25	1.71	59.34	1.74	7.22	1.74	86.82	2.61
50	8.71	2.36	59.36	1.74	8.72	2.40	87.02	2.61
51	9.98	2.74	59.43	1.74	10.01	2.82	87.26	2.62
52	11.28	6.04	59.44	1.74	11.29	6.25	87.32	2.62
53	6.44	1.19	59.53	1.75	6.35	1.31	87.97	2.65
54	7.15	4.56	59.70	1.75	7.12	4.63	88.71	2.67
55	8.66	6.17	59.85	1.75	8.68	6.34	89.13	2.68
56	10.13	7.44	59.73	1.75	10.15	7.69	88.54	2.66
57	8.62	9.66	62.55	1.84	8.65	9.97	99.84	3.10
58	10.22	11.88	61.57	1.81	10.23	12.29	95.62	2.93
59	11.50	12.98	60.32	1.77	11.50	13.42	90.73	2.74
60	6.73	4.98	62.94	1.87	6.67	5.14	102.82	3.25
61	8.61	12.99	70.01	2.12	8.64	13.42	122.15	4.18
62	10.31	16.26	66.81	1.99	10.32	16.83	112.04	3.65
63	6.83	11.20	70.58	3.03	6.80	11.05	127.38	6.43
64	8.70	17.30	70.59	4.64	8.73	17.16	123.80	9.39
65	5.80	0.64	154.85	8.07	5.79	0.59	154.02	7.25
66	7.55	2.62	156.07	8.11	7.55	2.40	155.23	7.30
67	8.37	3.35	156.58	8.11	8.43	3.12	155.74	7.29
68	9.04	3.29	157.10	8.13	9.17	3.12	156.25	7.31
69	9.90	6.38	157.58	8.20	10.11	6.18	156.73	7.37
70	5.63	1.70	161.06	8.97	5.63	1.58	160.29	8.06
71	7.66	6.99	162.04	9.00	7.66	6.38	161.26	8.08
72	8.37	9.13	161.12	8.76	8.43	8.48	160.32	7.87
73	9.03	9.05	160.90	8.67	9.18	8.60	160.08	7.79
74	8.39	14.56	178.34	12.29	8.45	13.54	177.75	11.02
75	9.11	14.65	176.18	11.65	9.25	13.93	175.56	10.46
76	10.09	13.93	169.37	10.14	10.29	13.51	168.66	9.11
77	6.70	5.83	188.63	16.52	6.67	5.35	188.97	14.95
78	8.41	19.73	194.32	19.71	8.46	18.37	195.54	18.13
79	9.19	20.15	193.35	18.58	9.33	19.18	193.00	16.66
80	10.15	19.76	185.95	14.99	10.35	19.15	185.49	13.45
81	7.35	15.17	200.41	44.22	7.33	13.87	200.29	38.46
82	7.43	22.37	190.53	130.75	7.40	20.56	190.61	116.47
83	5.77	1.19	170.13	14.95	5.77	1.19	171.49	14.76
84	7.51	3.39	171.55	15.06	7.45	3.30	172.93	14.87
85	8.79	5.17	172.30	15.07	8.76	4.98	173.70	14.88
86	9.25	5.19	172.82	15.10	9.23	4.98	174.24	14.91
87	9.55	9.05	173.77	15.19	9.55	8.70	175.18	15.00
88	5.78	3.24	177.89	17.02	5.77	3.24	179.17	16.73
89	7.46	9.43	179.07	17.06	7.42	9.19	180.36	16.78
90	8.64	13.62	179.11	16.83	8.60	13.11	180.42	16.55
91	9.11	13.52	177.51	16.15	9.08	12.97	178.86	15.87
92	8.64	21.26	188.54	22.08	8.60	20.47	189.81	21.83

93	9.14	21.32	186.56	19.95	9.12	20.47	188.00	19.73
94	9.65	18.93	181.53	17.54	9.66	18.23	182.81	17.25
95	6.24	9.19	188.05	24.58	6.23	9.15	189.14	24.29
96	8.67	28.37	196.16	33.61	8.62	27.32	196.88	33.23
97	9.21	28.88	193.43	27.32	9.18	27.74	194.39	27.01
98	9.72	26.54	188.65	21.78	9.73	25.58	189.95	21.54
99	6.80	20.84	191.67	66.25	6.77	20.57	192.17	65.44
100	7.01	25.43	173.75	219.61	6.97	25.12	174.26	216.51
101	6.38	13.99	140.93	530.40	6.37	13.94	141.26	518.96
102	6.09	9.81	114.42	834.65	6.09	9.77	114.76	817.23
103	5.80	0.69	165.62	11.30	5.82	0.72	169.19	12.14
104	7.61	2.85	167.02	11.37	7.57	3.01	170.62	12.22
105	8.40	3.72	167.67	11.37	8.31	3.82	171.32	12.22
106	8.96	3.61	168.31	11.40	8.86	3.65	171.99	12.24
107	9.66	6.77	168.54	11.46	9.55	6.80	172.20	12.31
108	5.62	1.83	169.17	12.14	5.63	1.91	169.46	12.78
109	7.72	7.73	170.85	12.23	7.68	8.12	171.18	12.87
110	8.38	10.18	170.67	12.01	8.30	10.43	171.77	12.71
111	8.92	9.88	170.76	11.93	8.82	10.00	172.73	12.70
112	8.39	16.18	179.15	15.03	8.32	16.57	179.14	14.00
113	8.98	15.92	179.19	14.68	8.89	16.12	179.28	14.76
114	9.83	14.71	175.78	13.35	9.74	14.81	176.03	14.04
115	6.71	6.23	186.86	16.13	6.75	6.66	190.93	17.67
116	8.41	21.85	194.64	19.49	8.33	23.29	198.00	21.84
117	7.37	17.20	199.39	52.93	7.37	18.21	200.02	58.48
118	8.52	35.54	195.29	59.36	8.47	36.19	196.47	65.69
119	7.52	23.86	188.01	173.39	7.50	25.07	188.50	200.49
120	7.05	13.93	160.83	361.23	7.08	14.46	161.42	433.25
121	8.66	55.83	155.66	279.12	8.62	55.77	156.96	334.48
122	6.52	9.98	134.37	632.07	6.44	10.32	135.32	763.84
123	6.49	0.42	58.36	2.05	6.42	0.42	80.76	2.93
124	7.21	1.70	58.47	2.05	7.21	1.72	81.30	2.94
125	8.50	2.21	58.51	2.05	8.46	2.20	81.50	2.94
126	9.80	2.49	58.54	2.05	9.73	2.45	81.68	2.94
127	11.24	5.54	58.53	2.05	11.17	5.38	81.69	2.94
128	6.46	1.17	58.74	2.06	6.39	1.20	82.44	3.00
129	7.10	4.56	58.86	2.06	7.10	4.60	83.04	3.01
130	8.41	5.75	58.95	2.06	8.35	5.71	83.35	3.02
131	9.94	6.77	58.81	2.05	9.85	6.61	82.79	2.99
132	8.37	9.03	61.59	2.17	8.30	8.96	93.01	3.47
133	10.03	10.85	60.55	2.12	9.94	10.61	89.09	3.28
134	6.75	5.04	62.28	2.21	6.73	5.08	96.08	3.64
135	8.35	12.16	69.15	2.49	8.29	12.07	114.46	4.64
136	6.83	11.33	72.90	3.75	6.83	11.38	122.55	7.45
137	8.46	16.19	73.54	5.85	8.42	16.16	119.65	11.14
138	6.75	17.71	71.80	8.76	6.75	18.32	113.39	16.76

Appendix D: Data of mooring line tensions of designed mooring system D

	Line1				Line2			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.83	0.61	142.60	8.13	5.84	0.67	143.28	9.16
2	7.62	2.41	143.50	8.15	7.61	2.65	144.19	9.18
3	8.45	3.20	143.88	8.14	8.39	3.46	144.58	9.17
4	9.18	3.20	144.30	8.15	9.05	3.40	145.00	9.18
5	10.16	6.42	144.53	8.22	9.95	6.65	145.23	9.26
6	5.66	1.62	147.15	8.99	5.66	1.76	147.77	10.14
7	7.69	6.58	147.96	8.97	7.69	7.24	148.60	10.13
8	8.41	8.75	147.17	8.75	8.35	9.46	147.83	9.87
9	9.16	8.88	147.07	8.66	9.01	9.39	147.74	9.76
10	8.42	14.08	162.11	12.05	8.35	15.19	162.60	13.63
11	9.22	14.48	160.56	11.44	9.08	15.27	161.09	12.92
12	6.68	5.39	170.82	16.23	6.70	5.93	171.17	18.40
13	7.38	14.37	179.03	47.85	7.40	15.80	179.16	54.84
14	8.54	29.69	174.33	51.41	8.49	31.90	174.55	59.04
15	7.50	19.74	168.76	143.33	7.51	21.47	168.92	173.42
16	6.55	0.47	73.77	3.01	6.67	0.44	56.09	2.31
17	7.24	1.91	74.06	3.02	7.25	1.90	56.14	2.31
18	8.53	2.48	74.19	3.02	8.48	2.43	56.16	2.31
19	9.86	2.82	74.34	3.02	9.80	2.73	56.19	2.31
20	6.51	1.29	74.78	3.06	6.62	1.21	56.26	2.32
21	7.17	4.87	75.17	3.07	7.18	4.84	56.33	2.32
22	8.61	6.49	75.45	3.08	8.56	6.32	56.40	2.32
23	8.64	10.18	83.79	3.51	8.59	9.88	58.13	2.40
24	6.75	5.24	86.90	3.70	6.81	5.16	58.68	2.43
25	8.65	13.67	102.43	4.64	8.61	13.27	63.11	2.65
26	6.84	11.50	108.90	7.22	6.87	11.34	64.89	3.80
27	8.76	18.38	103.70	10.22	8.73	17.75	63.41	5.63
28	6.74	17.37	96.55	14.48	6.77	17.62	60.47	8.08
29	6.62	14.03	74.17	19.40	6.66	14.02	54.39	13.30
30	5.97	0.97	159.44	11.82	5.98	0.93	156.12	11.10
31	7.31	3.55	160.60	11.85	7.34	3.39	157.25	11.13
32	8.34	4.51	161.16	11.86	8.44	4.42	157.77	11.14
33	9.26	4.69	161.72	11.88	9.34	4.65	158.30	11.16
34	10.24	9.25	161.80	11.91	10.29	9.17	158.41	11.19
35	5.83	2.70	162.05	12.51	5.85	2.58	158.97	11.76
36	7.30	9.44	163.13	12.55	7.33	9.03	160.01	11.79
37	8.34	12.07	163.06	12.37	8.42	11.82	159.85	11.62
38	9.30	12.63	163.34	12.32	9.38	12.49	160.08	11.57
39	8.35	18.98	172.09	15.67	8.43	18.58	169.72	14.73
40	9.36	20.08	171.52	15.21	9.44	19.86	169.02	14.29
41	10.45	19.75	167.74	13.74	10.50	19.55	164.88	12.91
42	6.58	9.21	176.75	19.63	6.51	9.16	175.10	18.46
43	8.38	24.48	180.97	23.29	8.45	25.03	179.69	21.89
44	9.44	27.45	180.59	22.10	9.52	27.16	179.17	20.77

45	6.89	19.41	180.90	45.47	6.86	19.41	180.28	42.93
46	8.56	33.86	177.50	46.70	8.63	33.29	176.80	44.80
47	6.73	25.91	168.62	94.23	6.71	26.23	168.08	89.39
48	5.88	1.12	156.62	15.61	5.88	1.12	155.10	15.76
49	7.33	2.97	157.72	15.65	7.37	3.04	156.18	15.80
50	8.91	4.63	158.35	15.67	8.94	4.79	156.79	15.82
51	9.74	5.12	158.93	15.70	9.73	5.28	157.35	15.86
52	10.54	10.16	158.84	15.69	10.50	10.41	157.27	15.84
53	5.86	3.11	157.83	16.02	5.83	3.51	156.39	16.18
54	7.31	8.20	159.05	16.11	7.36	8.39	157.59	16.26
55	8.55	15.07	159.84	16.19	8.88	12.84	158.35	16.34
56	9.73	13.71	159.71	15.99	9.73	14.12	158.18	16.14
57	8.85	19.58	167.71	19.83	8.88	20.22	166.58	20.02
58	9.80	21.87	164.89	18.20	9.79	22.54	163.60	18.37
59	10.77	21.80	161.27	16.62	10.72	22.31	159.82	16.77
60	6.15	9.02	168.79	21.40	6.15	9.06	167.83	21.61
61	8.87	26.53	176.56	28.56	8.90	27.42	175.93	28.82
62	9.87	30.16	173.03	24.08	9.87	31.10	172.19	24.30
63	6.55	18.07	173.60	43.19	6.57	18.26	173.22	43.72
64	9.00	37.29	171.12	62.16	9.02	38.72	170.66	62.73
65	6.06	0.81	146.59	7.46	6.04	0.87	147.31	8.23
66	7.30	2.96	147.57	7.48	7.30	3.18	148.30	8.26
67	8.44	3.84	148.00	7.48	8.38	4.07	148.74	8.26
68	9.42	4.09	148.47	7.50	9.35	4.28	149.21	8.28
69	10.51	8.28	148.74	7.54	10.41	8.59	149.47	8.32
70	5.93	2.24	151.75	8.18	5.91	2.39	152.42	9.02
71	7.27	7.82	152.60	8.19	7.28	8.40	153.28	9.03
72	8.42	10.18	151.73	8.00	8.38	10.81	152.43	8.82
73	9.50	11.00	151.60	7.92	9.41	11.51	152.31	8.75
74	8.43	15.98	167.15	11.02	8.38	16.97	167.66	12.15
75	9.57	17.49	165.69	10.54	9.48	18.30	166.24	11.63
76	10.75	17.73	159.53	9.23	10.64	18.37	160.15	10.18
77	6.56	8.11	174.89	14.55	6.56	8.67	175.24	16.03
78	8.44	21.49	179.80	17.47	8.40	22.82	180.08	19.25
79	9.66	23.92	178.95	16.33	9.57	25.02	179.26	18.00
80	10.79	24.86	173.88	13.43	10.69	25.77	174.28	14.81
81	6.86	17.08	180.82	35.85	6.86	18.27	180.97	39.36
82	6.71	24.65	170.49	74.28	6.73	24.82	170.65	82.76
83	6.58	0.46	73.50	2.37	6.68	0.44	56.85	2.10
84	7.20	1.93	73.74	2.37	7.21	1.91	56.90	2.09
85	8.20	2.28	73.85	2.37	8.24	2.29	56.91	2.09
86	9.53	2.45	73.94	2.37	9.60	2.49	56.93	2.09
87	11.17	5.46	74.02	2.37	11.22	5.61	56.95	2.09
88	6.53	1.28	75.02	2.42	6.63	1.23	57.13	2.12
89	7.12	4.94	75.35	2.43	7.13	4.88	57.20	2.12
90	8.23	5.84	75.54	2.43	8.30	5.90	57.26	2.11
91	9.79	6.70	74.99	2.41	9.88	6.86	57.16	2.11

92	8.25	9.13	85.35	2.83	8.32	9.22	59.69	2.23
93	9.95	10.81	81.26	2.65	10.03	11.05	58.79	2.19
94	11.40	11.86	76.97	2.48	11.45	12.15	57.71	2.13
95	6.78	5.37	89.57	3.01	6.81	5.28	60.59	2.29
96	8.28	12.28	106.68	3.86	8.35	12.39	66.42	2.58
97	10.08	14.88	96.72	3.34	10.15	15.18	63.54	2.42
98	11.46	16.68	85.67	2.84	11.50	17.04	60.22	2.25
99	6.83	12.03	120.16	6.46	6.86	11.51	69.61	3.37
100	6.76	18.34	114.62	16.19	6.77	17.65	69.81	7.58
101	6.62	14.52	90.08	24.66	6.64	14.54	63.14	12.37
102	6.52	13.77	73.63	31.51	6.59	13.33	57.86	17.92
103	5.83	0.77	162.10	12.85	5.80	0.72	159.01	11.84
104	7.62	3.07	163.30	12.89	7.68	2.89	160.16	11.87
105	8.33	3.96	163.88	12.88	8.43	3.86	160.71	11.87
106	8.89	3.80	164.47	12.90	8.98	3.74	161.27	11.89
107	9.61	7.14	164.51	13.00	9.70	7.06	161.33	11.97
108	5.65	2.01	164.41	14.01	5.63	1.91	161.55	12.89
109	7.70	8.46	165.53	14.00	7.75	8.02	162.63	12.88
110	8.28	10.86	165.56	13.73	8.36	10.56	162.56	12.63
111	8.81	10.42	165.89	13.60	8.90	10.25	162.85	12.52
112	8.27	17.83	173.78	18.18	8.36	16.87	171.63	16.69
113	8.86	17.38	173.35	17.40	8.95	16.58	171.07	15.99
114	9.74	15.55	169.89	15.44	9.82	15.35	167.27	14.20
115	6.69	7.11	177.84	23.84	6.65	6.61	176.37	21.85
116	8.29	24.23	181.78	28.83	8.36	23.56	180.65	26.39
117	7.44	18.28	181.20	70.44	7.46	17.22	180.67	63.99
118	8.44	36.00	178.47	74.31	8.49	35.30	177.57	71.06
119	7.54	24.15	169.16	236.65	7.57	22.97	168.75	209.33
120	7.07	14.57	145.78	495.83	7.09	13.84	145.19	420.58
121	8.61	54.05	141.70	380.45	8.65	53.77	140.40	322.17
122	6.41	10.74	125.24	818.08	6.47	10.36	124.63	698.12
123	5.82	1.16	149.28	19.74	5.82	1.16	147.87	20.00
124	7.56	3.54	150.27	19.77	7.61	3.63	148.84	20.04
125	8.70	5.11	150.81	19.79	8.74	5.31	149.37	20.05
126	9.18	5.04	151.33	19.81	9.19	5.25	149.87	20.08
127	9.59	8.71	151.23	19.86	9.57	9.05	149.78	20.13
128	5.81	3.22	150.55	20.79	5.81	3.24	149.19	21.07
129	7.42	9.38	151.69	20.85	7.48	9.61	150.30	21.13
130	8.55	13.00	152.42	20.85	8.60	13.52	151.03	21.13
131	9.05	12.83	152.17	20.45	9.07	13.37	150.75	20.73
132	8.54	20.23	161.47	26.48	8.59	21.02	160.33	26.83
133	9.09	20.23	158.08	23.88	9.11	21.07	156.82	24.18
134	6.26	9.39	163.18	29.59	6.27	9.40	162.19	29.98
135	8.57	27.01	172.69	40.41	8.62	28.05	172.00	40.93
136	6.87	18.65	170.09	70.58	6.90	18.89	169.74	72.11
137	8.83	39.85	168.72	123.61	8.86	41.47	168.22	125.62
138	6.94	23.11	153.17	267.14	6.97	23.36	152.85	272.39

	Line3				Line4			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.84	0.72	143.85	10.13	5.87	0.77	145.95	11.00
2	7.60	2.87	144.77	10.16	7.57	3.05	146.90	11.02
3	8.34	3.70	145.16	10.14	8.27	3.86	147.31	11.01
4	8.96	3.58	145.59	10.16	8.87	3.70	147.76	11.02
5	9.78	6.89	145.81	10.25	9.67	7.04	147.96	11.13
6	5.66	1.90	148.30	11.23	5.68	2.02	150.26	12.21
7	7.68	7.85	149.13	11.22	7.65	8.36	151.12	12.19
8	8.30	10.13	148.38	10.93	8.24	10.58	150.42	11.88
9	8.90	9.88	148.30	10.81	8.81	10.20	150.38	11.74
10	8.31	16.23	163.01	15.12	8.25	16.93	164.56	16.47
11	8.96	16.05	161.53	14.33	8.87	16.54	163.16	15.61
12	6.67	6.69	171.45	20.46	6.70	7.20	172.52	22.34
13	7.41	17.11	179.28	61.61	7.40	18.25	179.68	67.87
14	8.46	33.91	174.74	66.44	8.41	35.14	175.49	73.27
15	7.51	23.00	168.98	203.07	7.49	24.29	169.28	226.25
16	6.66	0.44	55.95	2.45	6.56	0.46	69.08	2.62
17	7.24	1.90	55.96	2.44	7.20	1.92	69.21	2.62
18	8.40	2.37	55.96	2.44	8.30	2.33	69.28	2.62
19	9.74	2.63	55.97	2.43	9.66	2.55	69.34	2.62
20	6.61	1.21	56.04	2.45	6.50	1.28	70.09	2.66
21	7.16	4.85	56.07	2.45	7.12	4.90	70.29	2.66
22	8.47	6.13	56.08	2.44	8.35	5.97	70.35	2.66
23	8.50	9.57	56.96	2.50	8.39	9.33	76.75	2.95
24	6.81	5.20	57.51	2.55	6.77	5.33	80.28	3.11
25	8.53	12.85	59.68	2.68	8.42	12.53	92.56	3.75
26	6.87	11.36	61.99	3.73	6.82	11.91	106.88	6.26
27	8.66	17.11	61.20	5.04	8.57	17.32	105.32	9.13
28	6.78	17.44	63.00	7.66	6.75	18.23	106.74	15.99
29	6.64	14.49	60.55	12.78	6.56	15.25	90.08	24.84
30	5.99	0.89	153.31	10.27	6.01	0.83	151.91	9.33
31	7.36	3.20	154.40	10.31	7.36	2.99	152.98	9.36
32	8.52	4.29	154.89	10.31	8.58	4.06	153.46	9.36
33	9.42	4.54	155.41	10.33	9.49	4.35	153.96	9.38
34	10.36	9.00	155.53	10.36	10.45	8.70	154.09	9.41
35	5.87	2.45	156.34	10.89	5.90	2.30	155.01	9.90
36	7.35	8.54	157.34	10.92	7.35	7.97	156.00	9.92
37	8.50	11.43	157.11	10.76	8.56	10.82	155.74	9.77
38	9.46	12.21	157.30	10.71	9.54	11.71	155.91	9.73
39	8.50	17.97	167.66	13.64	8.56	17.00	166.60	12.40
40	9.52	19.42	166.85	13.23	9.61	18.61	165.74	12.02
41	10.57	19.19	162.43	11.95	10.67	18.56	161.19	10.86
42	6.51	8.63	173.65	17.11	6.52	8.07	172.89	15.56
43	8.52	24.21	178.56	20.29	8.57	22.90	177.96	18.46
44	9.60	26.57	177.92	19.24	9.69	25.48	177.26	17.49
45	6.87	18.32	179.72	39.96	6.87	17.12	179.41	36.50

46	8.67	33.75	175.77	41.78	8.71	31.84	175.22	38.24
47	6.72	24.83	167.58	83.59	6.73	23.32	167.30	75.77
48	5.89	1.12	154.04	15.79	5.89	1.11	154.64	15.65
49	7.40	3.08	155.10	15.82	7.38	3.03	155.71	15.69
50	8.96	4.88	155.70	15.84	8.95	4.78	156.31	15.71
51	9.73	5.37	156.25	15.88	9.73	5.28	156.87	15.74
52	10.48	10.54	156.17	15.86	10.50	10.39	156.79	15.72
53	5.83	3.50	155.38	16.20	5.86	3.09	155.97	16.06
54	7.39	8.48	156.56	16.29	7.37	8.36	157.16	16.15
55	8.90	13.07	157.32	16.37	8.89	12.82	157.91	16.23
56	9.73	14.35	157.11	16.17	9.73	14.10	157.72	16.03
57	8.90	20.58	165.79	20.05	8.89	20.19	166.25	19.88
58	9.79	22.92	162.70	18.39	9.80	22.51	163.21	18.24
59	10.70	22.60	158.80	16.80	10.72	22.28	159.38	16.66
60	6.16	9.05	167.16	21.65	6.16	8.99	167.57	21.47
61	8.92	27.91	175.48	28.86	8.91	27.37	175.75	28.63
62	9.87	31.64	171.59	24.33	9.87	31.07	171.93	24.13
63	6.59	18.32	172.92	43.79	6.58	18.16	173.07	43.28
64	9.04	39.51	170.34	62.84	9.03	38.64	170.58	62.33
65	6.02	0.92	147.92	8.94	6.01	0.96	150.11	9.54
66	7.30	3.37	148.92	8.97	7.28	3.54	151.14	9.58
67	8.34	4.28	149.36	8.97	8.28	4.42	151.60	9.58
68	9.29	4.46	149.83	8.98	9.22	4.57	152.10	9.59
69	10.32	8.87	150.10	9.04	10.26	9.05	152.34	9.65
70	5.88	2.54	152.99	9.79	5.86	2.66	155.00	10.45
71	7.29	8.93	153.86	9.81	7.27	9.39	155.89	10.47
72	8.34	11.39	153.03	9.57	8.28	11.77	155.13	10.22
73	9.34	11.99	152.92	9.50	9.26	12.27	155.06	10.14
74	8.34	17.87	168.09	13.19	8.28	18.47	169.57	14.08
75	9.41	19.05	166.69	12.62	9.33	19.49	168.28	13.48
76	10.55	18.97	160.68	11.06	10.49	19.32	162.52	11.81
77	6.55	9.18	175.54	17.39	6.55	9.68	176.51	18.55
78	8.36	24.04	180.31	20.87	8.30	24.85	181.06	22.26
79	9.49	26.04	179.52	19.52	9.41	26.64	180.36	20.84
80	10.59	26.60	174.62	16.07	10.53	27.12	175.75	17.16
81	6.86	19.37	181.09	42.51	6.86	20.39	181.44	45.19
82	6.73	26.21	170.77	90.22	6.72	27.53	171.10	95.55
83	6.66	0.45	56.58	2.02	6.53	0.48	77.59	2.77
84	7.20	1.90	56.60	2.02	7.17	1.90	77.83	2.77
85	8.27	2.30	56.62	2.01	8.30	2.33	77.96	2.77
86	9.68	2.54	56.63	2.01	9.76	2.62	78.09	2.77
87	11.28	5.78	56.62	2.01	11.33	5.99	78.05	2.77
88	6.61	1.24	56.68	2.02	6.49	1.33	78.60	2.81
89	7.11	4.84	56.73	2.02	7.08	4.86	78.95	2.82
90	8.35	5.96	56.75	2.02	8.39	6.08	79.16	2.82
91	9.96	7.05	56.69	2.02	10.02	7.28	78.71	2.80
92	8.38	9.33	57.79	2.07	8.42	9.54	87.15	3.20

93	10.10	11.33	57.22	2.04	10.15	11.70	83.33	3.01
94	11.50	12.50	56.81	2.02	11.53	12.93	79.92	2.86
95	6.79	5.27	58.39	2.10	6.73	5.37	90.80	3.40
96	8.40	12.55	60.89	2.23	8.44	12.83	104.90	4.21
97	10.22	15.55	58.94	2.13	10.26	16.04	95.35	3.64
98	11.54	17.49	57.54	2.06	11.57	18.06	86.14	3.15
99	6.85	11.51	63.00	3.23	6.80	11.69	112.43	6.66
100	6.74	17.89	59.95	7.00	6.71	17.67	101.37	13.46
101	6.65	14.26	55.29	11.81	6.59	14.39	81.14	17.96
102	6.60	13.16	52.44	16.42	6.53	13.45	67.80	20.21
103	5.77	0.67	156.39	10.73	5.76	0.62	155.11	9.52
104	7.73	2.70	157.51	10.75	7.75	2.47	156.21	9.54
105	8.51	3.69	158.03	10.75	8.57	3.44	156.72	9.54
106	9.08	3.63	158.56	10.77	9.19	3.43	157.24	9.56
107	9.82	6.92	158.65	10.85	10.01	6.68	157.33	9.62
108	5.61	1.79	159.12	11.66	5.61	1.66	157.94	10.34
109	7.78	7.49	160.17	11.66	7.80	6.84	158.97	10.33
110	8.43	10.10	160.03	11.43	8.49	9.40	158.79	10.13
111	9.00	9.95	160.27	11.34	9.12	9.43	159.02	10.05
112	8.43	16.16	169.77	15.08	8.48	15.07	168.87	13.33
113	9.05	16.10	169.11	14.45	9.17	15.30	168.15	12.79
114	9.95	15.06	165.02	12.84	10.13	14.55	163.93	11.38
115	6.67	5.83	175.09	19.69	6.62	5.31	174.47	17.37
116	8.43	22.58	179.67	23.75	8.49	20.48	179.20	20.93
117	7.46	16.03	180.22	57.08	7.45	14.64	180.01	49.79
118	8.55	34.06	176.69	63.28	8.59	31.94	176.29	55.07
119	7.60	21.59	168.40	182.20	7.59	19.95	168.28	151.21
120	7.08	13.03	144.82	346.36	7.02	12.15	144.73	279.22
121	8.69	52.80	139.61	265.52	8.72	50.50	139.38	214.89
122	6.54	9.83	123.94	568.61	6.58	9.11	123.68	443.84
123	5.82	1.16	146.92	20.05	5.82	1.16	147.62	19.83
124	7.64	3.68	147.87	20.09	7.62	3.63	148.58	19.87
125	8.77	5.43	148.39	20.10	8.75	5.31	149.11	19.88
126	9.20	5.38	148.89	20.13	9.20	5.26	149.61	19.91
127	9.57	9.25	148.79	20.18	9.58	9.06	149.52	19.96
128	5.81	3.23	148.26	21.12	5.81	3.21	148.95	20.89
129	7.51	9.74	149.37	21.18	7.48	9.59	150.06	20.95
130	8.63	13.81	150.08	21.18	8.60	13.52	150.78	20.95
131	9.09	13.69	149.78	20.78	9.08	13.38	150.49	20.55
132	8.62	21.47	159.56	26.88	8.60	21.01	160.12	26.58
133	9.13	21.55	155.97	24.24	9.12	21.08	156.59	23.97
134	6.28	9.41	161.51	30.04	6.27	9.37	162.02	29.70
135	8.65	28.65	171.52	40.99	8.63	28.06	171.86	40.51
136	6.93	19.02	169.41	72.28	6.91	18.86	169.55	70.90
137	8.88	42.44	167.89	125.80	8.87	41.53	168.18	123.89
138	7.00	23.52	152.67	272.89	6.98	23.36	152.95	268.04

	Line5				Line6			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.87	0.77	145.87	11.00	5.84	0.72	143.79	10.13
2	7.57	3.05	146.82	11.02	7.60	2.87	144.70	10.15
3	8.27	3.86	147.24	11.01	8.34	3.70	145.10	10.14
4	8.87	3.70	147.68	11.02	8.96	3.59	145.53	10.15
5	9.67	7.05	147.88	11.12	9.78	6.89	145.74	10.25
6	5.67	2.02	150.18	12.21	5.66	1.90	148.23	11.23
7	7.65	8.36	151.04	12.19	7.68	7.86	149.07	11.21
8	8.24	10.59	150.35	11.88	8.30	10.14	148.31	10.93
9	8.81	10.20	150.30	11.73	8.90	9.89	148.23	10.80
10	8.25	16.94	164.47	16.47	8.31	16.24	162.95	15.12
11	8.87	16.55	163.08	15.60	8.96	16.05	161.46	14.33
12	6.70	7.20	172.43	22.34	6.67	6.69	171.38	20.46
13	7.40	18.25	179.58	67.86	7.41	17.11	179.21	61.59
14	8.41	35.15	175.38	73.25	8.46	33.92	174.66	66.42
15	7.49	24.29	169.12	226.19	7.51	22.99	168.85	202.99
16	5.82	1.16	147.39	19.80	5.82	1.16	146.79	20.03
17	7.61	3.62	148.35	19.84	7.64	3.68	147.74	20.07
18	8.75	5.31	148.86	19.85	8.76	5.42	148.25	20.08
19	9.19	5.25	149.36	19.87	9.20	5.37	148.75	20.10
20	5.81	3.22	148.72	20.86	5.81	3.22	148.14	21.10
21	7.48	9.59	149.83	20.92	7.51	9.74	149.24	21.16
22	8.60	13.51	150.55	20.92	8.62	13.81	149.95	21.16
23	8.59	21.01	159.94	26.55	8.62	21.47	159.46	26.86
24	6.27	9.38	161.85	29.66	6.28	9.41	161.41	30.01
25	8.62	28.05	171.75	40.47	8.65	28.67	171.47	40.96
26	6.91	18.87	169.39	70.62	6.92	19.03	169.33	72.13
27	8.87	41.52	168.05	123.64	8.88	42.44	167.82	125.67
28	6.98	23.38	152.82	267.24	7.00	23.50	152.59	272.48
29	6.30	13.73	126.64	589.63	6.31	13.70	126.25	603.43
30	5.76	0.62	155.07	9.53	5.77	0.67	156.37	10.73
31	7.74	2.46	156.18	9.55	7.73	2.70	157.50	10.76
32	8.57	3.43	156.68	9.54	8.51	3.69	158.01	10.76
33	9.19	3.43	157.21	9.56	9.08	3.63	158.55	10.77
34	10.01	6.68	157.30	9.63	9.82	6.92	158.63	10.85
35	5.61	1.66	157.90	10.34	5.61	1.79	159.10	11.67
36	7.80	6.84	158.92	10.33	7.78	7.49	160.14	11.66
37	8.49	9.39	158.74	10.14	8.43	10.10	160.00	11.44
38	9.12	9.43	158.97	10.06	9.00	9.95	160.25	11.34
39	8.48	15.06	168.81	13.33	8.43	16.16	169.74	15.08
40	9.17	15.29	168.09	12.79	9.05	16.10	169.08	14.45
41	10.13	14.54	163.88	11.38	9.95	15.05	165.00	12.85
42	6.63	5.31	174.40	17.37	6.60	6.10	175.05	19.69
43	8.49	20.47	179.12	20.94	8.43	22.58	179.63	23.76
44	9.24	21.05	178.57	19.42	9.12	22.13	179.14	22.01
45	7.45	14.64	179.93	49.81	7.46	16.02	180.18	57.10

46	8.59	31.93	176.22	55.09	8.55	34.05	176.66	63.29
47	7.59	19.95	168.21	151.30	7.60	21.59	168.38	182.28
48	6.53	0.48	76.47	2.75	6.66	0.45	56.07	2.03
49	7.17	1.90	76.74	2.75	7.20	1.90	56.10	2.03
50	8.31	2.33	76.88	2.76	8.27	2.30	56.12	2.02
51	9.76	2.62	77.02	2.76	9.68	2.54	56.14	2.03
52	11.32	5.99	77.00	2.76	11.28	5.78	56.14	2.02
53	6.49	1.32	77.59	2.80	6.61	1.24	56.21	2.04
54	7.09	4.86	77.94	2.81	7.11	4.84	56.25	2.03
55	8.40	6.08	78.09	2.81	8.35	5.96	56.25	2.03
56	10.02	7.28	77.67	2.79	9.96	7.04	56.20	2.02
57	8.42	9.54	85.97	3.18	8.38	9.33	57.17	2.08
58	10.15	11.69	82.26	3.00	10.10	11.33	56.67	2.05
59	11.53	12.92	78.92	2.85	11.50	12.49	56.31	2.03
60	6.73	5.37	90.00	3.40	6.79	5.27	57.95	2.11
61	8.44	12.83	103.54	4.16	8.40	12.54	59.87	2.22
62	10.26	16.04	94.14	3.61	10.22	15.54	58.14	2.13
63	6.80	11.69	111.51	6.65	6.85	11.53	62.13	3.24
64	8.54	16.95	103.55	9.07	8.51	16.61	58.92	4.65
65	6.00	0.97	150.12	9.55	6.02	0.92	147.95	8.94
66	7.28	3.54	151.14	9.58	7.30	3.38	148.94	8.97
67	8.28	4.42	151.61	9.58	8.34	4.28	149.39	8.97
68	9.22	4.56	152.10	9.59	9.29	4.46	149.86	8.98
69	10.25	9.04	152.34	9.65	10.32	8.87	150.13	9.04
70	5.86	2.66	154.99	10.45	5.88	2.54	153.00	9.79
71	7.27	9.40	155.89	10.47	7.29	8.94	153.87	9.81
72	8.28	11.77	155.13	10.22	8.34	11.39	153.05	9.57
73	9.26	12.27	155.06	10.14	9.33	11.99	152.94	9.50
74	8.28	18.48	169.54	14.08	8.34	17.87	168.09	13.19
75	9.33	19.49	168.25	13.48	9.40	19.05	166.70	12.62
76	10.49	19.34	162.51	11.81	10.55	18.96	160.69	11.06
77	6.55	9.69	176.46	18.56	6.55	9.19	175.52	17.39
78	8.30	24.86	180.99	22.27	8.36	24.05	180.28	20.87
79	9.41	26.63	180.30	20.85	9.49	26.04	179.49	19.53
80	10.53	27.12	175.70	17.17	10.59	26.60	174.60	16.08
81	6.86	20.40	181.38	45.21	6.86	19.38	181.07	42.53
82	6.72	27.55	171.06	95.64	6.73	26.23	170.79	90.30
83	5.89	1.12	154.88	15.67	5.88	1.12	154.17	15.80
84	7.38	3.03	155.95	15.71	7.40	3.08	155.23	15.84
85	8.95	4.78	156.56	15.73	8.96	4.88	155.83	15.86
86	9.73	5.27	157.12	15.77	9.73	5.37	156.39	15.89
87	10.50	10.39	157.05	15.75	10.48	10.54	156.31	15.88
88	5.86	3.10	156.17	16.08	5.86	3.11	155.49	16.21
89	7.37	8.36	157.37	16.17	7.39	8.49	156.68	16.30
90	8.88	12.82	158.13	16.25	8.90	13.07	157.44	16.38
91	9.73	14.10	157.96	16.05	9.73	14.35	157.24	16.18
92	8.89	20.19	166.39	19.90	8.90	20.58	165.87	20.06

93	9.80	22.51	163.39	18.26	9.79	22.92	162.80	18.40
94	10.72	22.28	159.60	16.68	10.58	23.11	158.93	16.82
95	6.16	9.00	167.67	21.48	6.16	9.05	167.22	21.65
96	8.91	27.37	175.81	28.63	8.92	27.91	175.53	28.86
97	9.87	31.06	172.03	24.14	9.87	31.64	171.65	24.34
98	10.76	31.52	166.06	19.76	10.74	32.00	165.53	19.93
99	6.58	18.17	173.10	43.33	6.59	18.32	172.94	43.82
100	6.48	25.65	154.94	85.10	6.51	24.26	154.73	85.73
101	5.95	20.94	129.36	94.80	5.95	21.02	129.03	95.42
102	5.81	17.24	108.33	84.24	5.81	17.29	107.84	84.94
103	6.01	0.83	151.93	9.34	5.99	0.88	153.32	10.28
104	7.36	2.99	153.00	9.36	7.36	3.20	154.41	10.31
105	8.58	4.07	153.48	9.36	8.52	4.29	154.90	10.31
106	9.49	4.35	153.99	9.38	9.42	4.54	155.42	10.33
107	10.45	8.69	154.12	9.41	10.36	9.00	155.54	10.36
108	5.90	2.29	155.04	9.90	5.87	2.45	156.35	10.89
109	7.35	7.96	156.03	9.92	7.35	8.54	157.35	10.92
110	8.56	10.82	155.76	9.77	8.50	11.43	157.12	10.76
111	9.54	11.70	155.93	9.73	9.46	12.21	157.31	10.71
112	8.56	17.00	166.65	12.40	8.50	17.96	167.68	13.64
113	9.61	18.61	165.78	12.03	9.53	19.41	166.87	13.24
114	10.67	18.55	161.22	10.86	10.57	19.19	162.44	11.95
115	6.52	8.07	172.95	15.56	6.51	8.63	173.68	17.11
116	8.57	22.89	178.03	18.46	8.52	24.20	178.59	20.30
117	6.87	17.12	179.50	36.51	6.87	18.31	179.77	39.97
118	8.71	31.83	175.29	38.24	8.67	33.74	175.81	41.79
119	6.73	23.31	167.41	75.78	6.72	24.82	167.65	83.61
120	6.05	20.42	143.50	87.11	6.03	20.52	143.86	93.86
121	8.88	48.77	136.68	67.91	8.89	49.57	137.43	73.03
122	5.78	18.71	122.60	87.47	5.74	18.75	123.10	92.67
123	6.56	0.46	67.37	2.60	6.67	0.44	55.40	2.46
124	7.20	1.91	67.49	2.59	7.24	1.90	55.41	2.45
125	8.30	2.32	67.54	2.59	8.39	2.37	55.41	2.44
126	9.67	2.54	67.59	2.59	9.74	2.63	55.42	2.44
127	11.24	5.70	67.61	2.59	11.25	5.89	55.42	2.44
128	6.50	1.27	68.45	2.64	6.61	1.21	55.53	2.47
129	7.12	4.88	68.60	2.64	7.15	4.83	55.55	2.46
130	8.36	5.95	68.62	2.63	8.47	6.11	55.53	2.45
131	9.95	6.99	68.20	2.61	10.02	7.24	55.48	2.45
132	8.39	9.30	74.90	2.91	8.50	9.54	56.34	2.51
133	10.10	11.27	71.82	2.78	10.16	11.63	55.90	2.48
134	6.77	5.31	78.71	3.09	6.81	5.18	57.01	2.56
135	8.43	12.49	90.48	3.71	8.53	12.81	58.78	2.68
136	6.82	11.85	105.01	6.22	6.87	11.31	61.25	3.87
137	8.58	17.23	101.01	8.83	8.66	17.00	59.03	5.06
138	6.75	18.08	104.51	15.82	6.78	17.32	61.25	7.72

	Line7				Line8			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	5.84	0.67	143.22	9.15	5.82	0.61	142.56	8.13
2	7.61	2.65	144.13	9.17	7.62	2.41	143.46	8.15
3	8.39	3.46	144.53	9.17	8.45	3.20	143.85	8.14
4	9.05	3.40	144.95	9.18	9.18	3.20	144.27	8.15
5	9.95	6.65	145.17	9.26	10.16	6.42	144.49	8.22
6	5.66	1.76	147.72	10.14	5.66	1.62	147.11	8.99
7	7.69	7.24	148.54	10.13	7.69	6.58	147.93	8.97
8	8.35	9.47	147.78	9.87	8.41	8.75	147.14	8.75
9	9.01	9.39	147.68	9.76	9.16	8.89	147.03	8.65
10	8.35	15.20	162.56	13.62	8.42	14.09	162.09	12.05
11	9.08	15.28	161.04	12.92	9.22	14.48	160.55	11.44
12	6.70	5.93	171.13	18.40	6.68	5.38	170.82	16.23
13	7.40	15.80	179.14	54.82	7.39	14.37	179.06	47.83
14	8.49	31.92	174.50	59.02	8.54	29.71	174.31	51.39
15	7.51	21.47	168.83	173.31	7.50	19.74	168.72	143.22
16	5.82	1.17	147.85	20.00	5.82	1.16	149.38	19.75
17	7.61	3.63	148.82	20.03	7.56	3.54	150.38	19.78
18	8.74	5.31	149.34	20.04	8.71	5.11	150.91	19.80
19	9.19	5.25	149.85	20.07	9.18	5.05	151.44	19.83
20	5.81	3.23	149.16	21.07	5.81	3.22	150.65	20.80
21	7.48	9.61	150.28	21.13	7.42	9.38	151.79	20.87
22	8.60	13.52	151.01	21.12	8.55	13.01	152.53	20.87
23	8.59	21.02	160.32	26.82	8.54	20.23	161.56	26.50
24	6.27	9.41	162.17	29.97	6.26	9.36	163.26	29.61
25	8.62	28.05	172.00	40.92	8.57	27.01	172.76	40.44
26	6.90	18.89	169.74	72.10	6.87	18.64	170.18	70.71
27	8.86	41.49	168.20	125.60	8.83	39.87	168.77	123.71
28	6.98	23.34	152.84	272.39	6.94	23.06	153.23	267.58
29	6.30	13.65	126.42	603.16	6.29	13.60	126.74	590.84
30	5.80	0.72	159.01	11.84	5.83	0.77	162.12	12.85
31	7.68	2.89	160.17	11.87	7.62	3.06	163.32	12.89
32	8.43	3.86	160.71	11.87	8.33	3.96	163.90	12.88
33	8.98	3.74	161.27	11.89	8.89	3.80	164.49	12.90
34	9.70	7.06	161.33	11.97	9.61	7.14	164.53	13.00
35	5.63	1.91	161.55	12.90	5.65	2.01	164.43	14.02
36	7.75	8.02	162.63	12.89	7.70	8.46	165.54	14.00
37	8.36	10.55	162.56	12.63	8.28	10.86	165.57	13.73
38	8.90	10.24	162.85	12.52	8.81	10.42	165.91	13.60
39	8.36	16.86	171.63	16.69	8.27	17.82	173.81	18.18
40	8.95	16.57	171.06	15.99	8.86	16.86	173.37	17.41
41	9.82	15.35	167.26	14.20	9.74	15.55	169.91	15.44
42	6.65	6.62	176.36	21.85	6.69	7.11	177.86	23.84
43	8.36	23.56	180.65	26.40	8.29	24.23	181.81	28.83
44	9.01	23.49	180.27	24.42	8.93	23.91	181.55	26.65
45	7.46	17.22	180.67	64.01	7.44	18.28	181.24	70.47

46	8.49	35.29	177.57	71.08	8.44	35.99	178.50	74.32
47	7.57	22.96	168.76	209.40	7.53	24.15	169.21	236.71
48	6.67	0.44	57.17	2.15	6.58	0.46	74.03	2.43
49	7.21	1.91	57.21	2.15	7.20	1.93	74.28	2.43
50	8.24	2.29	57.22	2.14	8.20	2.28	74.38	2.43
51	9.60	2.49	57.24	2.14	9.53	2.44	74.49	2.43
52	11.22	5.61	57.25	2.14	11.17	5.46	74.54	2.44
53	6.62	1.23	57.36	2.16	6.52	1.28	75.39	2.48
54	7.12	4.88	57.44	2.16	7.11	4.94	75.74	2.49
55	8.29	5.89	57.54	2.16	8.22	5.84	75.99	2.49
56	9.88	6.86	57.45	2.15	9.79	6.69	75.47	2.47
57	8.32	9.21	59.89	2.28	8.25	9.13	85.49	2.88
58	10.02	11.04	58.96	2.23	9.95	10.80	81.45	2.71
59	11.45	12.14	57.92	2.18	11.40	11.86	77.29	2.54
60	6.81	5.28	60.50	2.32	6.78	5.38	89.17	3.05
61	8.35	12.38	66.49	2.63	8.28	12.27	106.29	3.91
62	10.15	15.17	63.50	2.46	10.08	14.87	96.42	3.39
63	6.86	11.54	68.86	3.44	6.83	12.07	118.53	6.51
64	8.48	16.49	69.49	5.16	8.44	17.09	117.97	9.84
65	6.04	0.87	147.36	8.24	6.06	0.81	146.67	7.46
66	7.30	3.18	148.35	8.26	7.30	2.96	147.65	7.48
67	8.38	4.07	148.79	8.26	8.43	3.84	148.08	7.48
68	9.35	4.28	149.25	8.28	9.42	4.09	148.54	7.50
69	10.41	8.59	149.52	8.32	10.51	8.28	148.82	7.54
70	5.91	2.39	152.46	9.02	5.93	2.24	151.82	8.18
71	7.28	8.41	153.32	9.04	7.27	7.83	152.68	8.19
72	8.37	10.81	152.48	8.82	8.42	10.18	151.82	8.00
73	9.41	11.51	152.37	8.75	9.49	11.00	151.69	7.93
74	8.38	16.97	167.70	12.16	8.43	15.98	167.22	11.02
75	9.48	18.30	166.27	11.63	9.57	17.49	165.77	10.54
76	10.64	18.36	160.20	10.19	10.74	17.71	159.61	9.23
77	6.56	8.67	175.26	16.04	6.56	8.12	174.96	14.56
78	8.40	22.82	180.09	19.25	8.44	21.50	179.87	17.47
79	9.57	25.02	179.27	18.00	9.66	23.91	179.01	16.33
80	10.69	25.77	174.30	14.82	10.79	24.86	173.95	13.43
81	6.86	18.29	180.99	39.37	6.86	17.10	180.90	35.87
82	6.73	24.84	170.73	82.83	6.71	24.67	170.65	74.35
83	5.88	1.12	155.12	15.76	5.88	1.12	156.52	15.60
84	7.37	3.04	156.20	15.80	7.33	2.98	157.62	15.64
85	8.94	4.79	156.81	15.82	8.92	4.63	158.24	15.66
86	9.73	5.28	157.37	15.85	9.74	5.12	158.82	15.69
87	10.50	10.41	157.30	15.84	10.54	10.16	158.74	15.67
88	5.86	3.12	156.40	16.17	5.86	3.11	157.75	16.01
89	7.27	8.80	157.61	16.26	7.32	8.20	158.97	16.10
90	8.88	12.84	158.37	16.35	8.85	12.44	159.75	16.18
91	9.73	14.12	158.20	16.14	9.73	13.71	159.61	15.98
92	8.88	20.23	166.60	20.02	8.85	19.59	167.66	19.83

93	9.79	22.54	163.62	18.37	9.80	21.88	164.82	18.19
94	10.72	22.31	159.84	16.78	10.77	21.81	161.19	16.61
95	6.15	9.06	167.85	21.60	6.15	9.02	168.76	21.40
96	8.90	27.43	175.96	28.82	8.87	26.54	176.56	28.56
97	9.87	31.11	172.21	24.30	9.87	30.17	173.02	24.08
98	10.76	31.58	166.28	19.89	10.81	30.85	167.36	19.70
99	6.57	18.25	173.24	43.73	6.55	18.06	173.61	43.17
100	6.50	24.21	154.94	85.51	6.46	25.55	155.25	84.71
101	5.94	21.04	129.15	95.07	5.94	20.96	129.41	94.16
102	5.80	17.33	107.92	84.56	5.80	17.28	108.19	83.58
103	5.98	0.93	156.11	11.10	5.97	0.97	159.41	11.82
104	7.33	3.38	157.24	11.13	7.31	3.55	160.58	11.85
105	8.44	4.42	157.76	11.14	8.34	4.51	161.13	11.86
106	9.34	4.64	158.30	11.16	9.26	4.69	161.70	11.88
107	10.29	9.16	158.40	11.19	10.24	9.25	161.78	11.91
108	5.85	2.58	158.96	11.76	5.83	2.69	162.02	12.51
109	7.33	9.03	159.99	11.79	7.30	9.44	163.10	12.55
110	8.42	11.82	159.84	11.62	8.34	12.07	163.03	12.37
111	9.38	12.49	160.07	11.57	9.30	12.63	163.31	12.32
112	8.43	18.58	169.71	14.73	8.35	18.98	172.06	15.67
113	9.44	19.85	169.01	14.30	9.36	20.08	171.48	15.22
114	10.50	19.55	164.87	12.91	10.45	19.74	167.71	13.75
115	6.51	9.16	175.10	18.46	6.51	9.66	176.72	19.64
116	8.45	25.03	179.69	21.90	8.38	24.48	180.94	23.29
117	6.86	19.41	180.29	42.94	6.89	19.40	180.87	45.49
118	8.63	33.28	176.80	44.81	8.56	33.85	177.47	46.72
119	6.71	26.23	168.10	89.41	6.73	25.91	168.60	94.26
120	6.00	21.82	144.47	99.01	6.00	21.22	145.15	102.95
121	8.82	51.11	138.70	76.87	8.81	49.41	140.16	79.71
122	5.69	20.10	123.95	96.08	5.67	19.29	124.64	97.51
123	6.66	0.44	56.56	2.38	6.54	0.47	74.16	3.08
124	7.25	1.90	56.61	2.37	7.24	1.91	74.42	3.09
125	8.48	2.42	56.63	2.37	8.52	2.47	74.54	3.09
126	9.80	2.72	56.66	2.37	9.86	2.81	74.68	3.09
127	11.26	6.10	56.66	2.37	11.26	6.30	74.67	3.09
128	6.62	1.21	56.66	2.38	6.50	1.29	75.00	3.13
129	7.17	4.83	56.74	2.37	7.16	4.86	75.38	3.14
130	8.56	6.30	56.83	2.38	8.61	6.47	75.70	3.15
131	10.07	7.52	56.79	2.37	10.10	7.78	75.35	3.13
132	8.59	9.85	58.50	2.46	8.63	10.15	83.74	3.58
133	10.20	12.06	57.87	2.43	10.22	12.46	80.38	3.39
134	6.80	5.15	58.84	2.48	6.75	5.24	86.45	3.75
135	8.61	13.22	63.40	2.72	8.65	13.63	101.96	4.72
136	6.87	11.30	64.47	3.87	6.83	11.48	107.38	7.28
137	8.73	17.62	64.17	5.92	8.75	18.26	103.26	10.57
138	6.76	17.53	59.87	8.39	6.73	17.33	94.36	14.80

	Line9				Line10			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	6.05	0.81	139.10	8.17	6.03	0.87	139.80	9.02
2	7.29	2.96	139.96	8.19	7.29	3.17	140.67	9.04
3	8.43	3.83	140.31	8.20	8.38	4.06	141.03	9.04
4	9.43	4.08	140.72	8.21	9.35	4.28	141.43	9.05
5	10.51	8.27	140.98	8.24	10.41	8.58	141.69	9.09
6	5.92	2.24	143.89	8.82	5.90	2.40	144.56	9.72
7	7.27	7.82	144.66	8.83	7.28	8.39	145.33	9.74
8	8.42	10.18	143.79	8.65	8.37	10.80	144.48	9.54
9	9.49	10.99	143.63	8.59	9.41	11.51	144.33	9.47
10	8.43	15.98	159.53	11.47	8.38	16.96	160.07	12.64
11	9.57	17.48	157.82	11.02	9.48	18.29	158.39	12.15
12	6.55	8.12	169.06	14.85	6.55	8.67	169.44	16.37
13	6.86	17.09	178.45	35.90	6.85	18.28	178.58	39.38
14	8.59	29.36	173.09	36.95	8.56	31.28	173.36	40.48
15	6.70	24.68	167.83	74.31	6.72	24.86	167.94	82.91
16	6.58	0.46	69.03	2.60	6.68	0.44	55.92	2.43
17	7.20	1.93	69.23	2.60	7.21	1.91	55.96	2.42
18	8.20	2.28	69.29	2.59	8.24	2.29	55.97	2.42
19	9.53	2.45	69.38	2.60	9.60	2.49	55.98	2.42
20	6.53	1.28	70.26	2.64	6.63	1.23	56.12	2.45
21	7.12	4.94	70.52	2.65	7.13	4.88	56.18	2.44
22	8.23	5.84	70.67	2.65	8.30	5.90	56.23	2.44
23	8.25	9.13	78.77	3.01	8.32	9.22	58.04	2.55
24	6.78	5.37	82.37	3.19	6.81	5.28	58.72	2.60
25	8.28	12.28	97.67	3.99	8.35	12.39	63.26	2.86
26	6.83	12.03	110.89	6.61	6.86	11.51	65.86	3.66
27	8.45	17.15	109.24	9.72	8.49	16.54	65.28	5.41
28	6.76	18.33	106.55	16.51	6.77	17.65	66.06	8.19
29	6.62	14.51	84.51	25.45	6.64	14.54	60.73	13.40
30	5.83	0.77	162.12	12.85	5.80	0.72	159.02	11.84
31	7.62	3.06	163.32	12.89	7.68	2.89	160.18	11.87
32	8.33	3.96	163.90	12.88	8.43	3.86	160.73	11.87
33	8.89	3.80	164.48	12.90	8.98	3.74	161.28	11.89
34	9.61	7.14	164.52	13.00	9.70	7.06	161.34	11.97
35	5.65	2.01	164.42	14.01	5.63	1.91	161.56	12.89
36	7.70	8.46	165.54	14.00	7.75	8.02	162.64	12.88
37	8.28	10.86	165.57	13.73	8.36	10.56	162.57	12.63
38	8.81	10.42	165.90	13.60	8.90	10.25	162.86	12.52
39	8.27	17.83	173.79	18.18	8.36	16.87	171.63	16.69
40	8.86	17.38	173.36	17.40	8.95	16.58	171.07	15.99
41	9.74	15.55	169.90	15.44	9.82	15.36	167.28	14.20
42	6.69	7.11	177.85	23.84	6.65	6.62	176.37	21.85
43	8.29	24.23	181.79	28.83	8.36	23.57	180.66	26.39
44	8.93	23.91	181.54	26.65	9.01	23.50	180.28	24.42
45	7.44	18.28	181.21	70.45	7.46	17.22	180.68	63.99

46	8.44	36.00	178.48	74.31	8.49	35.30	177.58	71.07
47	7.54	24.13	169.18	236.66	7.57	22.96	168.76	209.35
48	5.81	1.17	159.05	19.03	5.82	1.17	157.71	19.28
49	7.54	3.53	160.19	19.07	7.60	3.63	158.83	19.32
50	8.70	5.09	160.84	19.09	8.74	5.30	159.46	19.34
51	9.17	5.03	161.43	19.12	9.19	5.24	160.04	19.36
52	9.59	8.70	161.33	19.17	9.57	9.03	159.94	19.41
53	5.81	3.25	160.05	20.10	5.81	3.25	158.77	20.36
54	7.41	9.38	161.30	20.17	7.47	9.61	160.00	20.43
55	8.55	12.99	162.12	20.17	8.59	13.50	160.81	20.43
56	9.05	12.81	162.08	19.77	9.07	13.36	160.73	20.02
57	8.54	20.22	169.35	25.88	8.59	21.00	168.35	26.20
58	9.08	20.22	166.80	23.24	9.11	21.05	165.66	23.53
59	9.70	18.15	163.48	20.80	9.68	18.82	162.20	21.07
60	6.26	9.43	170.14	28.99	6.27	9.44	169.28	29.37
61	8.57	27.00	177.44	39.87	8.61	28.06	176.87	40.37
62	9.15	27.43	174.25	32.27	9.17	28.54	173.49	32.67
63	6.86	18.70	173.74	69.49	6.90	18.95	173.46	70.99
64	8.83	39.86	172.56	121.44	8.86	41.49	172.15	123.39
65	5.82	0.61	150.00	7.31	5.83	0.67	150.65	8.23
66	7.61	2.41	151.02	7.33	7.60	2.65	151.68	8.25
67	8.44	3.19	151.48	7.33	8.38	3.45	152.15	8.24
68	9.18	3.19	151.96	7.33	9.05	3.39	152.64	8.26
69	10.16	6.41	152.19	7.41	9.95	6.64	152.86	8.34
70	5.66	1.63	154.83	8.21	5.66	1.77	155.41	9.26
71	7.69	6.57	155.72	8.21	7.68	7.23	156.31	9.25
72	8.41	8.74	154.96	7.97	8.34	9.45	155.58	8.98
73	9.16	8.87	154.89	7.87	9.01	9.38	155.52	8.86
74	8.41	14.07	169.40	11.42	8.35	15.18	169.80	12.89
75	9.22	14.47	168.11	10.79	9.08	15.26	168.55	12.18
76	10.29	14.06	162.36	9.31	10.09	14.55	162.88	10.49
77	6.67	5.40	176.34	15.68	6.70	5.94	176.58	17.76
78	8.43	19.18	180.91	19.12	8.37	20.65	181.08	21.68
79	9.30	19.99	180.23	17.47	9.15	21.06	180.43	19.78
80	10.33	19.94	175.61	14.00	10.13	20.63	175.91	15.83
81	7.38	14.36	181.32	47.04	7.39	15.80	181.38	53.88
82	7.49	19.78	171.10	138.21	7.50	21.53	171.36	168.97
83	6.55	0.47	79.25	2.77	6.67	0.44	57.04	2.00
84	7.24	1.91	79.61	2.78	7.25	1.90	57.11	2.00
85	8.53	2.48	79.78	2.78	8.48	2.43	57.14	2.00
86	9.86	2.82	79.95	2.78	9.80	2.73	57.17	2.00
87	11.26	6.31	79.96	2.78	11.25	6.11	57.18	2.00
88	6.51	1.29	80.50	2.83	6.62	1.21	57.29	2.01
89	7.17	4.87	80.97	2.84	7.18	4.84	57.38	2.01
90	8.62	6.49	81.32	2.85	8.56	6.32	57.47	2.01
91	10.09	7.79	80.87	2.83	10.06	7.54	57.39	2.01
92	8.64	10.18	91.24	3.32	8.59	9.88	59.79	2.10

93	10.21	12.48	87.26	3.12	10.19	12.08	58.98	2.07
94	11.47	13.56	82.87	2.91	11.47	13.15	57.94	2.03
95	6.75	5.24	94.82	3.52	6.81	5.16	60.53	2.14
96	8.65	13.67	111.90	4.50	8.61	13.27	66.23	2.40
97	10.32	17.09	102.71	3.93	10.31	16.56	63.66	2.27
98	11.51	18.94	91.79	3.34	11.52	18.40	60.44	2.13
99	6.84	11.50	118.25	7.06	6.87	11.34	68.46	3.48
100	6.74	17.39	104.43	14.13	6.77	17.62	62.95	7.33
101	6.62	14.03	78.90	18.55	6.66	14.02	55.28	11.91
102	6.56	13.07	63.73	21.61	6.60	12.99	51.83	16.70
103	5.97	0.97	159.43	11.81	5.98	0.93	156.11	11.10
104	7.31	3.55	160.59	11.85	7.33	3.38	157.23	11.13
105	8.34	4.52	161.15	11.86	8.44	4.42	157.75	11.14
106	9.26	4.69	161.71	11.88	9.34	4.65	158.29	11.16
107	10.24	9.25	161.80	11.91	10.29	9.16	158.40	11.19
108	5.83	2.70	162.05	12.51	5.85	2.58	158.96	11.76
109	7.30	9.44	163.12	12.55	7.33	9.03	160.00	11.79
110	8.34	12.07	163.06	12.37	8.42	11.82	159.84	11.62
111	9.30	12.63	163.34	12.32	9.38	12.49	160.07	11.57
112	8.35	18.98	172.08	15.67	8.43	18.58	169.71	14.73
113	9.36	20.08	171.52	15.21	9.44	19.86	169.01	14.29
114	10.45	19.74	167.73	13.74	10.50	19.55	164.87	12.91
115	6.58	9.21	176.75	19.63	6.51	9.16	175.10	18.46
116	8.38	24.48	180.97	23.28	8.45	25.03	179.69	21.89
117	6.89	19.41	180.90	45.47	6.86	19.41	180.28	42.93
118	8.56	33.86	177.49	46.69	8.63	33.29	176.79	44.80
119	6.73	25.91	168.61	94.22	6.71	26.23	168.06	89.37
120	6.00	21.22	145.13	102.82	6.00	21.82	144.34	98.91
121	8.82	49.47	140.10	79.51	8.82	51.19	138.50	76.70
122	5.67	19.29	124.49	97.18	5.69	20.09	123.62	95.84
123	5.88	1.13	146.51	16.04	5.88	1.13	144.93	16.20
124	7.32	2.98	147.46	16.08	7.36	3.04	145.87	16.24
125	8.91	4.63	147.98	16.09	8.94	4.78	146.37	16.26
126	9.74	5.12	148.48	16.13	9.73	5.28	146.85	16.29
127	10.54	10.15	148.40	16.11	10.50	10.40	146.78	16.27
128	5.86	3.12	147.98	16.43	5.86	3.13	146.47	16.59
129	7.31	8.21	149.08	16.51	7.36	8.39	147.55	16.68
130	8.85	12.43	149.78	16.59	8.88	12.84	148.23	16.76
131	9.73	13.71	149.45	16.40	9.70	14.72	147.86	16.56
132	8.85	19.58	159.43	20.13	8.88	20.22	158.18	20.32
133	9.80	21.87	155.77	18.53	9.79	22.54	154.38	18.71
134	6.15	9.05	161.47	21.66	6.15	9.09	160.37	21.87
135	8.87	26.53	171.52	28.70	8.90	27.42	170.76	28.97
136	6.54	18.09	169.87	43.49	6.57	18.28	169.40	44.03
137	9.00	37.28	166.80	62.24	9.02	38.71	166.23	62.82
138	6.47	24.08	151.71	84.53	6.50	24.25	151.37	85.36

	Line11				Line12			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	6.01	0.92	140.39	9.79	5.99	0.97	142.58	10.44
2	7.30	3.37	141.27	9.81	7.28	3.53	143.49	10.47
3	8.34	4.27	141.63	9.81	8.27	4.40	143.87	10.47
4	9.29	4.46	142.04	9.83	9.22	4.56	144.30	10.49
5	10.32	8.86	142.30	9.87	10.25	9.03	144.54	10.53
6	5.87	2.54	145.12	10.55	5.85	2.67	147.20	11.25
7	7.28	8.93	145.91	10.56	7.27	9.38	148.01	11.27
8	8.34	11.37	145.06	10.35	8.27	11.75	147.22	11.04
9	9.34	11.98	144.93	10.29	9.26	12.26	147.11	10.98
10	8.34	17.86	160.53	13.71	8.28	18.46	162.19	14.63
11	9.40	19.04	158.87	13.18	9.33	19.48	160.62	14.06
12	6.54	9.19	169.76	17.74	6.54	9.69	170.93	18.92
13	6.85	19.38	178.69	42.52	6.85	20.40	179.12	45.19
14	8.53	33.05	173.59	43.64	8.50	32.58	174.42	46.31
15	6.72	26.24	168.03	89.64	6.71	27.56	168.39	94.87
16	6.66	0.45	56.03	2.35	6.53	0.48	73.07	3.04
17	7.20	1.90	56.05	2.34	7.17	1.90	73.26	3.04
18	8.27	2.30	56.06	2.35	8.30	2.33	73.35	3.04
19	9.68	2.54	56.07	2.34	9.76	2.62	73.46	3.04
20	6.61	1.25	56.10	2.35	6.49	1.33	73.86	3.08
21	7.11	4.84	56.14	2.35	7.08	4.86	74.15	3.08
22	8.35	5.96	56.15	2.35	8.39	6.08	74.31	3.09
23	8.38	9.34	56.92	2.39	8.42	9.53	80.89	3.43
24	6.79	5.27	57.37	2.41	6.73	5.38	84.02	3.62
25	8.40	12.55	59.26	2.53	8.44	12.83	96.55	4.38
26	6.85	11.51	60.91	3.62	6.80	11.69	103.97	6.86
27	8.52	16.63	59.87	5.37	8.54	16.95	98.67	9.68
28	6.74	17.89	58.44	7.85	6.71	17.67	94.38	13.88
29	6.65	14.26	54.64	13.22	6.59	14.40	76.78	18.80
30	5.77	0.67	156.39	10.73	5.76	0.62	155.11	9.52
31	7.73	2.70	157.52	10.75	7.75	2.47	156.21	9.54
32	8.51	3.69	158.04	10.76	8.57	3.44	156.72	9.54
33	9.08	3.63	158.57	10.77	9.19	3.43	157.24	9.56
34	9.82	6.93	158.65	10.85	10.01	6.68	157.34	9.62
35	5.61	1.79	159.12	11.66	5.61	1.66	157.94	10.34
36	7.78	7.49	160.17	11.66	7.80	6.84	158.97	10.33
37	8.43	10.10	160.03	11.43	8.49	9.40	158.79	10.13
38	9.00	9.95	160.28	11.33	9.12	9.43	159.01	10.05
39	8.43	16.16	169.77	15.08	8.48	15.07	168.87	13.33
40	9.05	16.11	169.11	14.45	9.17	15.30	168.15	12.79
41	9.95	15.06	165.03	12.84	10.13	14.55	163.93	11.38
42	6.67	5.83	175.09	19.69	6.62	5.31	174.47	17.37
43	8.43	22.59	179.67	23.75	8.49	20.48	179.20	20.93
44	9.12	22.14	179.18	22.00	9.24	21.06	178.65	19.42
45	7.46	16.02	180.21	57.08	7.44	14.64	180.00	49.80

46	8.55	34.06	176.69	63.28	8.59	31.94	176.28	55.07
47	7.60	21.59	168.40	182.22	7.59	19.95	168.27	151.23
48	5.82	1.17	156.80	19.32	5.82	1.16	157.48	19.12
49	7.63	3.67	157.90	19.36	7.60	3.62	158.59	19.16
50	8.76	5.41	158.52	19.38	8.74	5.29	159.22	19.17
51	9.20	5.36	159.10	19.41	9.19	5.24	159.80	19.20
52	9.56	9.23	159.00	19.46	9.57	9.04	159.70	19.25
53	5.81	3.24	157.89	20.40	5.81	3.23	158.55	20.18
54	7.50	9.74	159.12	20.47	7.47	9.59	159.78	20.26
55	8.62	13.80	159.91	20.47	8.60	13.50	160.58	20.26
56	9.09	13.67	159.81	20.07	9.08	13.36	160.50	19.85
57	8.61	21.46	167.66	26.25	8.59	21.00	168.17	25.96
58	9.12	21.54	164.88	23.57	9.11	21.07	165.46	23.31
59	9.67	19.22	161.32	21.11	9.68	18.84	161.97	20.88
60	6.27	9.44	168.69	29.42	6.27	9.41	169.13	29.09
61	8.64	28.65	176.48	40.42	8.62	28.05	176.76	39.96
62	9.19	29.20	172.97	32.72	9.18	28.56	173.34	32.35
63	6.92	19.08	173.19	71.14	6.90	18.91	173.30	69.80
64	8.88	42.45	171.88	123.54	8.86	41.54	172.11	121.67
65	5.84	0.72	151.21	9.09	5.86	0.77	153.27	9.86
66	7.59	2.86	152.24	9.12	7.56	3.05	154.33	9.89
67	8.34	3.69	152.71	9.11	8.27	3.85	154.82	9.89
68	8.95	3.57	153.21	9.13	8.86	3.69	155.34	9.90
69	9.78	6.88	153.43	9.22	9.67	7.03	155.53	10.01
70	5.66	1.91	155.90	10.25	5.67	2.03	157.76	11.14
71	7.67	7.84	156.81	10.23	7.65	8.35	158.70	11.12
72	8.30	10.12	156.09	9.94	8.24	10.57	158.05	10.79
73	8.90	9.87	156.05	9.80	8.81	10.18	158.05	10.65
74	8.31	16.22	170.13	14.30	8.25	16.92	171.46	15.57
75	8.96	16.03	168.91	13.50	8.87	16.53	170.34	14.68
76	9.92	15.04	163.32	11.62	9.81	15.37	165.00	12.62
77	6.72	6.45	176.79	19.74	6.69	7.21	177.63	21.54
78	8.32	22.70	181.23	24.12	8.26	23.67	181.86	26.34
79	9.03	22.08	180.60	21.98	8.94	23.48	181.32	23.99
80	9.97	21.34	176.15	17.56	9.87	21.82	177.14	19.14
81	7.40	17.12	181.42	60.51	7.39	18.26	181.70	66.63
82	7.50	23.08	171.37	197.85	7.48	24.41	171.58	222.20
83	6.66	0.44	56.52	2.10	6.56	0.46	72.83	2.37
84	7.24	1.90	56.53	2.09	7.20	1.92	73.01	2.37
85	8.40	2.37	56.54	2.09	8.30	2.33	73.09	2.37
86	9.74	2.63	56.55	2.09	9.66	2.55	73.18	2.37
87	11.25	5.90	56.55	2.09	11.23	5.71	73.21	2.37
88	6.61	1.21	56.66	2.11	6.50	1.28	74.10	2.41
89	7.16	4.85	56.69	2.11	7.12	4.90	74.36	2.41
90	8.47	6.13	56.71	2.10	8.35	5.97	74.44	2.42
91	10.02	7.26	56.64	2.09	9.94	7.01	73.93	2.40
92	8.50	9.57	57.90	2.17	8.39	9.33	82.29	2.73

93	10.16	11.66	57.25	2.13	10.10	11.29	78.46	2.57
94	11.48	12.74	56.78	2.11	11.47	12.40	75.15	2.44
95	6.81	5.19	58.63	2.22	6.77	5.33	86.46	2.91
96	8.53	12.85	61.48	2.37	8.42	12.53	100.47	3.59
97	10.28	16.01	59.23	2.24	10.23	15.54	90.38	3.09
98	11.53	17.88	57.62	2.15	11.52	17.43	81.21	2.69
99	6.87	11.36	64.42	3.43	6.82	11.91	115.32	6.08
100	6.78	17.45	65.54	6.97	6.75	18.24	114.00	15.60
101	6.64	14.49	62.40	11.72	6.59	14.64	95.23	24.05
102	6.57	13.41	58.63	16.33	6.49	14.06	81.46	29.45
103	5.99	0.89	153.30	10.27	6.01	0.83	151.89	9.33
104	7.36	3.20	154.38	10.31	7.36	2.99	152.95	9.36
105	8.52	4.29	154.88	10.31	8.58	4.06	153.43	9.36
106	9.42	4.54	155.39	10.33	9.49	4.35	153.94	9.38
107	10.36	9.00	155.51	10.36	10.45	8.70	154.07	9.41
108	5.87	2.45	156.33	10.89	5.90	2.30	155.00	9.90
109	7.35	8.54	157.33	10.92	7.35	7.97	155.99	9.92
110	8.50	11.43	157.10	10.76	8.56	10.82	155.72	9.77
111	9.46	12.21	157.29	10.71	9.54	11.70	155.89	9.73
112	8.50	17.97	167.64	13.64	8.56	17.00	166.58	12.40
113	9.52	19.42	166.84	13.23	9.61	18.61	165.73	12.03
114	10.57	19.19	162.42	11.95	10.67	18.57	161.17	10.86
115	6.51	8.63	173.64	17.11	6.52	8.07	172.87	15.56
116	8.52	24.21	178.54	20.29	8.57	22.90	177.94	18.46
117	6.87	18.32	179.71	39.96	6.87	17.13	179.39	36.50
118	8.67	33.75	175.75	41.78	8.71	31.84	175.19	38.24
119	6.72	24.83	167.55	83.59	6.73	23.32	167.25	75.77
120	6.03	20.52	143.63	93.78	6.05	20.42	143.15	87.06
121	8.89	49.65	137.08	72.88	8.89	48.85	136.18	67.79
122	5.74	18.74	122.57	92.50	5.78	18.70	121.86	87.35
123	5.88	1.13	143.85	16.24	5.89	1.12	144.49	16.09
124	7.39	3.08	144.77	16.27	7.37	3.03	145.41	16.12
125	8.96	4.87	145.25	16.28	8.94	4.78	145.91	16.14
126	9.73	5.37	145.72	16.32	9.73	5.27	146.38	16.18
127	10.48	10.53	145.66	16.30	10.50	10.38	146.32	16.16
128	5.86	3.12	145.43	16.62	5.86	3.11	146.06	16.49
129	7.39	8.49	146.49	16.71	7.37	8.36	147.12	16.57
130	8.89	13.06	147.16	16.79	8.88	12.82	147.79	16.64
131	9.72	14.34	146.76	16.59	9.73	14.10	147.41	16.45
132	8.90	20.57	157.30	20.35	8.88	20.19	157.83	20.18
133	9.79	22.91	153.41	18.74	9.80	22.50	153.98	18.58
134	6.16	9.07	159.62	21.91	6.16	9.02	160.10	21.73
135	8.92	27.91	170.22	29.01	8.91	27.37	170.55	28.78
136	6.59	18.34	169.03	44.10	6.58	18.19	169.22	43.60
137	9.04	39.50	165.85	62.93	9.03	38.63	166.15	62.43
138	6.51	24.30	151.18	85.61	6.50	24.13	151.48	85.01

	Line13				Line14			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	6.00	0.97	142.57	10.44	6.01	0.92	140.36	9.78
2	7.28	3.53	143.47	10.47	7.30	3.37	141.23	9.81
3	8.27	4.41	143.87	10.47	8.34	4.27	141.61	9.81
4	9.22	4.56	144.29	10.48	9.29	4.46	142.02	9.83
5	10.25	9.04	144.53	10.53	10.32	8.87	142.26	9.87
6	5.85	2.67	147.19	11.25	5.87	2.54	145.10	10.54
7	7.27	9.38	148.00	11.27	7.28	8.92	145.88	10.56
8	8.27	11.76	147.21	11.04	8.34	11.37	145.04	10.35
9	9.26	12.27	147.10	10.97	9.34	11.99	144.90	10.29
10	8.28	18.46	162.21	14.63	8.34	17.86	160.52	13.71
11	9.33	19.49	160.64	14.06	9.40	19.05	158.86	13.18
12	6.54	9.69	170.96	18.91	6.54	9.19	169.77	17.73
13	6.85	20.40	179.18	45.16	6.85	19.38	178.72	42.50
14	8.50	32.59	174.45	46.29	8.53	33.06	173.59	43.62
15	6.71	27.57	168.42	94.80	6.72	26.25	168.00	89.57
16	5.89	1.12	144.70	16.12	5.88	1.13	143.96	16.25
17	7.37	3.03	145.63	16.15	7.39	3.08	144.88	16.28
18	8.94	4.78	146.13	16.17	8.96	4.87	145.37	16.30
19	9.73	5.27	146.61	16.20	9.73	5.37	145.84	16.33
20	5.86	3.11	146.24	16.50	5.86	3.13	145.52	16.64
21	7.36	8.37	147.32	16.59	7.39	8.49	146.59	16.72
22	8.88	12.82	147.99	16.66	8.90	13.06	147.26	16.80
23	8.88	20.18	157.96	20.20	8.90	20.58	157.37	20.36
24	6.16	9.03	160.18	21.74	6.16	9.08	159.66	21.91
25	8.90	27.36	170.61	28.78	8.92	27.91	170.26	29.01
26	6.58	18.20	169.25	43.64	6.59	18.35	169.05	44.13
27	9.02	38.62	166.12	62.43	9.04	39.50	165.83	62.93
28	6.50	24.13	151.38	84.93	6.51	24.29	151.12	85.56
29	5.95	20.96	125.65	94.79	5.95	21.04	125.26	95.41
30	6.01	0.83	151.93	9.34	5.99	0.88	153.32	10.28
31	7.36	2.99	153.00	9.36	7.36	3.20	154.41	10.31
32	8.58	4.07	153.48	9.36	8.52	4.29	154.90	10.31
33	9.49	4.35	153.99	9.38	9.42	4.54	155.42	10.33
34	10.45	8.69	154.12	9.41	10.36	9.00	155.54	10.36
35	5.90	2.30	155.04	9.90	5.87	2.45	156.35	10.89
36	7.35	7.96	156.02	9.92	7.35	8.54	157.35	10.92
37	8.56	10.82	155.76	9.77	8.50	11.43	157.12	10.76
38	9.54	11.70	155.94	9.74	9.46	12.21	157.31	10.71
39	8.56	17.00	166.64	12.40	8.50	17.96	167.68	13.64
40	9.61	18.61	165.78	12.03	9.53	19.41	166.87	13.24
41	10.67	18.56	161.22	10.86	10.57	19.19	162.45	11.95
42	6.52	8.07	172.94	15.56	6.51	8.63	173.67	17.11
43	8.57	22.89	178.02	18.46	8.52	24.20	178.59	20.30
44	9.69	25.47	177.31	17.50	9.60	26.56	177.94	19.25
45	6.87	17.12	179.48	36.51	6.87	18.31	179.76	39.97

46	8.71	31.83	175.28	38.24	8.67	33.74	175.80	41.79
47	6.73	23.31	167.38	75.78	6.72	24.82	167.63	83.61
48	6.56	0.46	70.96	2.34	6.67	0.44	55.91	2.11
49	7.20	1.91	71.12	2.34	7.24	1.90	55.92	2.10
50	8.30	2.32	71.19	2.34	8.39	2.37	55.93	2.10
51	9.67	2.54	71.26	2.34	9.74	2.63	55.94	2.10
52	11.24	5.70	71.29	2.34	11.25	5.89	55.94	2.10
53	6.50	1.27	72.31	2.39	6.61	1.21	56.09	2.12
54	7.12	4.88	72.52	2.39	7.15	4.83	56.11	2.11
55	8.36	5.95	72.53	2.39	8.47	6.11	56.09	2.11
56	9.95	6.99	72.02	2.37	10.02	7.24	56.02	2.11
57	8.39	9.30	80.28	2.70	8.50	9.54	57.18	2.17
58	10.10	11.27	76.53	2.54	10.16	11.63	56.59	2.14
59	11.48	12.38	73.28	2.41	11.48	12.72	56.17	2.12
60	6.77	5.31	84.84	2.89	6.81	5.18	58.10	2.23
61	8.43	12.49	98.33	3.54	8.53	12.81	60.42	2.36
62	10.23	15.51	88.35	3.06	10.29	15.97	58.35	2.24
63	6.82	11.85	113.62	6.04	6.87	11.31	63.59	3.55
64	8.58	17.23	109.48	8.56	8.66	17.00	60.79	4.52
65	5.86	0.77	153.34	9.87	5.84	0.72	151.27	9.10
66	7.56	3.05	154.41	9.90	7.59	2.87	152.31	9.12
67	8.27	3.85	154.90	9.89	8.34	3.69	152.78	9.11
68	8.86	3.69	155.41	9.90	8.95	3.58	153.28	9.13
69	9.67	7.03	155.61	10.01	9.78	6.88	153.49	9.22
70	5.67	2.03	157.83	11.14	5.66	1.91	155.96	10.25
71	7.65	8.35	158.77	11.12	7.67	7.85	156.87	10.24
72	8.24	10.57	158.14	10.79	8.30	10.12	156.16	9.94
73	8.81	10.19	158.14	10.65	8.90	9.87	156.13	9.81
74	8.25	16.92	171.54	15.57	8.31	16.22	170.20	14.30
75	8.87	16.53	170.42	14.69	8.96	16.03	168.98	13.50
76	9.81	15.38	165.09	12.63	9.92	15.04	163.39	11.62
77	6.69	7.22	177.72	21.54	6.72	6.45	176.85	19.74
78	8.26	23.68	181.95	26.35	8.32	22.70	181.29	24.12
79	8.94	23.48	181.41	23.99	9.03	22.08	180.66	21.99
80	9.87	21.82	177.24	19.14	9.97	21.34	176.22	17.57
81	7.39	18.27	181.80	66.64	7.40	17.13	181.50	60.52
82	7.48	24.41	171.74	222.29	7.50	23.09	171.50	197.98
83	5.82	1.17	157.21	19.08	5.82	1.17	156.65	19.30
84	7.60	3.62	158.31	19.12	7.63	3.67	157.75	19.35
85	8.74	5.29	158.94	19.14	8.76	5.41	158.37	19.36
86	9.19	5.24	159.52	19.16	9.20	5.36	158.95	19.38
87	9.57	9.04	159.42	19.22	9.56	9.23	158.85	19.44
88	5.81	3.24	158.29	20.15	5.81	3.24	157.76	20.38
89	7.47	9.59	159.52	20.21	7.50	9.74	158.98	20.45
90	8.60	13.50	160.31	20.22	8.62	13.80	159.77	20.46
91	9.08	13.36	160.22	19.82	9.09	13.67	159.66	20.04
92	8.59	21.00	167.97	25.92	8.61	21.46	167.56	26.23

93	9.11	21.06	165.23	23.27	9.12	21.54	164.76	23.55
94	9.68	18.83	161.71	20.85	9.67	19.22	161.19	21.09
95	6.27	9.42	168.96	29.05	6.27	9.47	168.60	29.40
96	8.62	28.04	176.66	39.92	8.64	28.65	176.43	40.41
97	9.18	28.56	173.20	32.31	9.19	29.21	172.90	32.70
98	9.75	26.41	167.68	25.53	9.74	26.94	167.27	25.84
99	6.90	18.93	173.16	69.53	6.92	19.08	173.12	71.00
100	6.97	23.52	155.98	262.71	6.99	23.66	155.81	267.84
101	6.30	13.86	130.01	578.86	6.31	13.84	129.68	592.27
102	6.08	10.72	108.65	862.27	6.07	10.72	108.04	878.61
103	5.76	0.62	155.06	9.53	5.77	0.67	156.36	10.73
104	7.74	2.46	156.16	9.55	7.73	2.70	157.48	10.76
105	8.57	3.43	156.67	9.54	8.51	3.69	158.00	10.76
106	9.19	3.43	157.19	9.56	9.08	3.63	158.54	10.77
107	10.01	6.68	157.28	9.63	9.82	6.92	158.62	10.85
108	5.61	1.66	157.88	10.34	5.61	1.79	159.09	11.67
109	7.80	6.84	158.91	10.33	7.78	7.49	160.13	11.66
110	8.49	9.39	158.73	10.14	8.43	10.10	159.99	11.44
111	9.12	9.43	158.95	10.06	9.00	9.95	160.24	11.34
112	8.48	15.06	168.80	13.33	8.43	16.15	169.73	15.08
113	9.17	15.29	168.07	12.79	9.05	16.10	169.06	14.45
114	10.13	14.54	163.86	11.38	9.95	15.05	164.99	12.85
115	6.63	5.31	174.39	17.37	6.60	6.10	175.04	19.69
116	8.49	20.47	179.11	20.94	8.43	22.58	179.62	23.76
117	7.45	14.64	179.91	49.81	7.46	16.02	180.17	57.10
118	8.59	31.93	176.21	55.09	8.55	34.05	176.65	63.30
119	7.59	19.94	168.20	151.31	7.60	21.59	168.37	182.29
120	7.02	12.17	144.65	279.72	7.08	13.05	144.83	346.83
121	8.72	50.45	139.32	215.47	8.68	52.75	139.65	266.13
122	6.58	9.15	123.74	445.53	6.54	9.87	124.10	570.25
123	6.53	0.48	71.85	3.02	6.66	0.45	55.53	2.37
124	7.17	1.90	72.07	3.02	7.20	1.90	55.55	2.36
125	8.31	2.33	72.18	3.02	8.27	2.30	55.57	2.36
126	9.76	2.62	72.29	3.02	9.68	2.54	55.58	2.36
127	11.32	5.99	72.26	3.02	11.28	5.78	55.58	2.36
128	6.49	1.33	72.75	3.06	6.61	1.24	55.63	2.37
129	7.09	4.86	73.03	3.07	7.11	4.85	55.66	2.36
130	8.40	6.08	73.16	3.07	8.35	5.96	55.66	2.36
131	10.02	7.28	72.81	3.05	9.96	7.04	55.63	2.36
132	8.42	9.54	79.65	3.41	8.38	9.33	56.34	2.40
133	10.15	11.69	76.56	3.24	10.10	11.33	55.97	2.38
134	6.73	5.37	83.07	3.61	6.79	5.27	56.91	2.43
135	8.44	12.83	95.09	4.34	8.40	12.55	58.36	2.52
136	6.80	11.70	102.83	6.84	6.85	11.53	60.10	3.63
137	8.54	16.95	95.23	9.41	8.51	16.61	57.56	5.29
138	6.71	17.73	92.12	13.73	6.75	17.95	56.83	7.89

	Line15				Line16			
Case	WF Tz	WF StDev	LF Tz	LF StDev	WF Tz	WF StDev	LF Tz	LF StDev
1	6.02	0.87	139.74	9.02	6.05	0.81	139.02	8.17
2	7.29	3.17	140.61	9.04	7.29	2.96	139.88	8.19
3	8.38	4.06	140.98	9.04	8.43	3.83	140.24	8.20
4	9.35	4.28	141.38	9.05	9.42	4.08	140.64	8.21
5	10.40	8.58	141.64	9.09	10.51	8.27	140.90	8.24
6	5.90	2.40	144.51	9.72	5.92	2.25	143.81	8.81
7	7.28	8.40	145.29	9.73	7.27	7.82	144.58	8.83
8	8.37	10.80	144.43	9.54	8.42	10.18	143.71	8.65
9	9.41	11.51	144.28	9.47	9.49	10.99	143.56	8.59
10	8.38	16.96	160.03	12.64	8.43	15.98	159.45	11.47
11	9.48	18.30	158.35	12.14	9.57	17.48	157.74	11.02
12	6.55	8.68	169.41	16.36	6.55	8.12	168.98	14.85
13	6.85	18.29	178.57	39.37	6.85	17.09	178.38	35.89
14	8.56	31.29	173.32	40.46	8.59	29.38	172.99	36.94
15	6.72	24.86	167.85	82.86	6.70	24.69	167.66	74.27
16	5.88	1.13	144.95	16.20	5.88	1.13	146.41	16.03
17	7.36	3.04	145.88	16.24	7.32	2.98	147.36	16.07
18	8.94	4.78	146.38	16.26	8.91	4.63	147.87	16.08
19	9.73	5.28	146.86	16.29	9.74	5.12	148.37	16.12
20	5.86	3.13	146.48	16.59	5.86	3.12	147.89	16.42
21	7.36	8.39	147.56	16.68	7.31	8.20	148.99	16.50
22	8.88	12.84	148.24	16.75	8.81	12.98	149.69	16.58
23	8.88	20.22	158.19	20.32	8.85	19.59	159.38	20.12
24	6.15	9.08	160.38	21.87	6.15	9.04	161.43	21.65
25	8.90	27.42	170.77	28.96	8.87	26.54	171.52	28.70
26	6.57	18.28	169.41	44.03	6.55	18.09	169.87	43.47
27	9.02	38.72	166.22	62.80	9.00	37.30	166.80	62.22
28	6.50	24.23	151.36	85.34	6.48	24.04	151.74	84.54
29	5.94	21.06	125.39	95.05	5.94	20.98	125.69	94.15
30	5.98	0.93	156.12	11.10	5.97	0.97	159.42	11.82
31	7.33	3.38	157.24	11.13	7.31	3.55	160.59	11.85
32	8.44	4.42	157.77	11.14	8.34	4.51	161.14	11.86
33	9.34	4.64	158.30	11.16	9.26	4.69	161.71	11.88
34	10.29	9.16	158.41	11.19	10.24	9.25	161.79	11.91
35	5.85	2.58	158.97	11.76	5.83	2.69	162.03	12.51
36	7.33	9.03	160.00	11.79	7.30	9.44	163.10	12.55
37	8.42	11.82	159.84	11.62	8.34	12.07	163.04	12.37
38	9.38	12.49	160.08	11.57	9.30	12.63	163.33	12.32
39	8.43	18.58	169.72	14.73	8.35	18.98	172.07	15.67
40	9.44	19.85	169.02	14.30	9.36	20.07	171.49	15.22
41	10.50	19.55	164.88	12.91	10.45	19.75	167.72	13.75
42	6.51	9.15	175.10	18.46	6.51	9.66	176.72	19.64
43	8.45	25.03	179.69	21.90	8.38	24.48	180.94	23.29
44	9.52	27.15	179.17	20.78	9.44	27.44	180.56	22.11
45	6.86	19.41	180.29	42.94	6.89	19.40	180.88	45.49

46	8.63	33.28	176.80	44.81	8.56	33.85	177.48	46.71
47	6.71	26.23	168.09	89.40	6.73	25.91	168.61	94.26
48	6.66	0.44	57.50	2.05	6.54	0.47	79.38	2.83
49	7.25	1.90	57.56	2.05	7.24	1.91	79.71	2.83
50	8.48	2.42	57.59	2.05	8.52	2.47	79.87	2.84
51	9.80	2.72	57.63	2.05	9.86	2.81	80.04	2.84
52	11.26	6.10	57.63	2.05	11.26	6.30	80.02	2.84
53	6.62	1.21	57.66	2.06	6.50	1.29	80.44	2.89
54	7.17	4.83	57.76	2.06	7.16	4.86	80.92	2.90
55	8.56	6.30	57.89	2.06	8.61	6.47	81.32	2.91
56	10.07	7.52	57.82	2.06	10.10	7.78	80.88	2.88
57	8.59	9.85	60.14	2.15	8.64	10.15	90.95	3.37
58	10.20	12.06	59.29	2.12	10.22	12.46	86.98	3.17
59	11.48	13.13	58.28	2.08	11.47	13.55	82.72	2.97
60	6.80	5.15	60.55	2.18	6.75	5.24	94.00	3.55
61	8.61	13.22	66.44	2.45	8.65	13.63	111.16	4.56
62	10.31	16.52	63.73	2.32	10.32	17.06	101.99	3.97
63	6.87	11.30	67.74	3.52	6.83	11.48	116.40	7.10
64	8.73	17.63	67.47	5.37	8.75	18.26	112.27	10.29
65	5.83	0.67	150.71	8.23	5.82	0.61	150.03	7.31
66	7.60	2.65	151.74	8.25	7.61	2.41	151.05	7.33
67	8.38	3.45	152.20	8.25	8.44	3.19	151.51	7.33
68	9.05	3.39	152.69	8.26	9.18	3.19	151.99	7.34
69	9.95	6.64	152.91	8.34	10.16	6.41	152.23	7.41
70	5.66	1.77	155.45	9.26	5.66	1.63	154.85	8.21
71	7.68	7.24	156.36	9.25	7.69	6.57	155.75	8.21
72	8.34	9.45	155.63	8.98	8.41	8.74	154.99	7.97
73	9.01	9.38	155.58	8.86	9.16	8.87	154.93	7.87
74	8.35	15.19	169.84	12.90	8.41	14.07	169.40	11.42
75	9.07	15.27	168.59	12.18	9.22	14.47	168.12	10.79
76	10.09	14.55	162.93	10.49	10.29	14.06	162.38	9.30
77	6.70	5.94	176.62	17.76	6.67	5.40	176.33	15.69
78	8.37	20.66	181.11	21.68	8.43	19.18	180.89	19.12
79	9.15	21.06	180.45	19.78	9.30	20.00	180.20	17.48
80	10.13	20.64	175.94	15.83	10.33	19.94	175.60	14.01
81	7.39	15.81	181.41	53.91	7.38	14.37	181.30	47.07
82	7.50	21.55	171.45	169.11	7.49	19.80	171.14	138.36
83	5.82	1.17	157.69	19.27	5.81	1.17	159.18	19.04
84	7.59	3.62	158.81	19.32	7.54	3.54	160.32	19.09
85	8.74	5.30	159.44	19.34	8.70	5.10	160.97	19.10
86	9.19	5.24	160.03	19.36	9.17	5.03	161.57	19.14
87	9.57	9.03	159.93	19.41	9.59	8.70	161.47	19.19
88	5.81	3.25	158.75	20.35	5.81	3.24	160.18	20.12
89	7.47	9.61	159.99	20.43	7.42	9.38	161.43	20.19
90	8.59	13.51	160.79	20.43	8.55	13.00	162.25	20.19
91	9.07	13.36	160.71	20.02	9.05	12.82	162.21	19.78
92	8.59	21.01	168.35	26.20	8.54	20.22	169.46	25.89

93	9.11	21.05	165.66	23.53	9.08	20.22	166.92	23.26
94	9.68	18.82	162.19	21.07	9.70	18.16	163.62	20.82
95	6.27	9.44	169.28	29.37	6.26	9.40	170.23	29.02
96	8.61	28.06	176.89	40.37	8.57	27.00	177.52	39.91
97	9.18	28.55	173.50	32.67	9.15	27.44	174.34	32.30
98	9.74	26.40	168.07	25.82	9.77	25.47	169.21	25.53
99	6.90	18.94	173.46	70.98	6.86	18.69	173.82	69.62
100	6.97	23.47	156.02	267.84	6.94	23.18	156.35	263.25
101	6.30	13.78	129.84	592.27	6.29	13.73	130.13	580.54
102	6.07	10.70	108.14	877.66	6.07	10.65	108.50	863.16
103	5.80	0.72	159.00	11.84	5.83	0.77	162.12	12.85
104	7.68	2.89	160.16	11.87	7.62	3.06	163.32	12.89
105	8.43	3.86	160.71	11.87	8.33	3.96	163.90	12.88
106	8.98	3.74	161.27	11.89	8.89	3.80	164.48	12.90
107	9.70	7.06	161.33	11.97	9.61	7.14	164.52	13.00
108	5.63	1.91	161.54	12.90	5.65	2.01	164.43	14.02
109	7.75	8.02	162.62	12.89	7.70	8.46	165.54	14.00
110	8.36	10.55	162.55	12.63	8.28	10.86	165.57	13.73
111	8.90	10.24	162.84	12.52	8.81	10.42	165.90	13.60
112	8.36	16.86	171.62	16.69	8.27	17.82	173.81	18.18
113	8.95	16.58	171.06	15.99	8.86	16.86	173.37	17.40
114	9.82	15.35	167.26	14.20	9.74	15.55	169.91	15.44
115	6.65	6.62	176.36	21.85	6.69	7.11	177.86	23.84
116	8.36	23.56	180.64	26.40	8.29	24.22	181.81	28.83
117	7.46	17.21	180.67	64.01	7.44	18.28	181.24	70.46
118	8.49	35.29	177.57	71.08	8.44	35.99	178.50	74.31
119	7.57	22.96	168.77	209.41	7.53	24.15	169.22	236.72
120	7.09	13.85	145.27	421.01	7.07	14.58	145.94	496.17
121	8.64	53.73	140.53	322.75	8.61	54.00	141.93	381.00
122	6.48	10.41	124.89	699.60	6.41	10.78	125.59	819.26
123	6.67	0.44	56.26	2.49	6.58	0.46	69.68	2.67
124	7.21	1.91	56.29	2.49	7.20	1.93	69.87	2.67
125	8.24	2.29	56.30	2.48	8.20	2.28	69.95	2.67
126	9.60	2.49	56.32	2.48	9.52	2.44	70.04	2.67
127	11.22	5.61	56.33	2.48	11.17	5.46	70.08	2.67
128	6.62	1.23	56.40	2.50	6.52	1.28	70.76	2.71
129	7.12	4.88	56.46	2.50	7.11	4.94	71.03	2.72
130	8.29	5.89	56.53	2.50	8.22	5.84	71.23	2.72
131	9.88	6.86	56.46	2.49	9.79	6.69	70.81	2.70
132	8.32	9.21	58.28	2.60	8.25	9.13	79.06	3.08
133	10.02	11.04	57.58	2.56	9.95	10.80	75.68	2.92
134	6.81	5.28	58.76	2.65	6.78	5.38	82.25	3.24
135	8.35	12.39	63.41	2.91	8.28	12.27	97.50	4.06
136	6.86	11.54	65.37	3.74	6.83	12.07	109.57	6.66
137	8.48	16.49	65.84	5.65	8.44	17.09	108.94	10.15
138	6.77	17.74	65.12	8.45	6.76	18.46	103.95	16.76

References

ABS, 2018. Guide for fatigue assessment of offshore structures, American Bureau of Shipping.

ANSYS, 2017. ANSYS workbench documentation. Ansys Inc.

API RP 2FP1, 1993. Recommended Practice for Design, Analysis and Maintenance of Moorings for Floating Production Systems, First ed. American Petroleum Institute.

API RP 2SK, 1995. Design and Analysis of Stationkeeping Systems for Floating Structures, First ed. American Petroleum Institute.

API RP 2SK, 2008. Design and analysis of stationkeeping systems for floating structures, Third Edition. American Petroleum Institute.

API RP 2MET, 2014. Derivation of Metocean Design and Operating Conditions, first ed. American Petroleum Institute.

API RP 2SM, 2001. Design, Manufacture, Installation, and Maintenance of Synthetic Fiber Ropes for Offshore Mooring, First Edition. American Petroleum Institute.

Arredondo, A., Altuzarra, J., Mena, A., Fernández, J., 2018. Stress Intensity Factors in Fitness-for-Service Assessment of Cracks in Mooring Chains. In: Proceedings of ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering. American Society of Mechanical Engineers Digital Collection.

Asano, K., Ishikawa, K., Kataoka, F., Uno, K., Sakay, Y., 1986. Fatigue Properties of Mooring Chains for Offshore Structures. In: Proceedings of the Fifth International Conference on Offshore Mechanics and Arctic Engineering, Vol. III, pp. 529-536.

Banfield, S., Ridge, I. M., 2017. Fatigue durability of nylon rope for permanent mooring design. In OCEANS 2017-Aberdeen (pp. 1-9). IEEE.

Banfield, S., Versavel, T., Snell, R. O., Ahilan, R. V., 2000. Fatigue Curves for Polyester Moorings. In: Proceedings of 32nd Annual Offshore Technology Conference.

Barltrop, N.D.P., 1998. Floating Structures: a Guide for Design and Analysis. The Centre for Marine and Petroleum Technology. Oilfield Publications Limited.

Bastid, P., Smith, S. D., 2013. Numerical analysis of contact stresses between mooring chain links and potential consequences for fatigue damage. In: Proceedings of ASME 2013 32nd International Conference on Ocean, Offshore and Arctic Engineering. American Society of Mechanical Engineers Digital Collection.

Bendat, J. C.,1958. Principles and Applications of Random Noise Theory, John Wiley, New York.

Benasciutti D, Tovo R., 2005. Spectral methods for lifetime prediction under wide-band stationary random processes. International journal of fatigue, 27(8):867–77.

Benasciutti, D., Tovo, R., 2006. Comparison of spectral methods for fatigue analysis of broad-band Gaussian random processes. Probabilistic Engineering Mechanics, 21(4), 287-299.

Benasciutti, D., Tovo, R., 2007. On fatigue damage assessment in bimodal random processes. International journal of fatigue, 29(2): 232-244.

Bolt, H. M., Billington, C. J., Humphries, M. J., 1995. Anchor Chain-New Data, New Design Lines and Practical Details. In: Proceedings of Offshore Technology Conference. Offshore Technology Conference.

Brown, M. G., Hall, T. D., Marr, D. G., English, M., Snell, R. O., 2005. Floating production mooring integrity JIP-key findings. In: Proceedings of Offshore Technology Conference.

Buckle, A. K., 1974. Anchoring and Mooring Equipment on Ships. Naval Architect.

Bureau Veritas, 2014. Fatigue of Top Chain of Mooring Lines due to In-plane and Out-of-plane Bendings. Guidance Note NI, 604.

Chang, A., Li, H., Wang, S., Du, J., 2017. Probabilistic analysis and fatigue damage assessment of offshore mooring system due to non-Gaussian bimodal tension processes. Journal of Ocean University of China, 16(4), 585-601.

Chaplin, C.R., Rebel, G., Ridge, I. M. L., 2000. Tension/torsion interactions in multicomponent mooring lines. In: proceedings of Offshore Technology Conference.

Chen, L., Basu, B., 2018. Fatigue load estimation of a spar-type floating offshore wind turbine considering wave-current interactions. International Journal of Fatigue, 116, 421-428.

Chevillotte, Y., Marco, Y., Davies, P., Bles, G., Arhant, M., 2018. Fatigue of polyamide mooring ropes for floating wind turbines. In MATEC Web of Conferences (Vol. 165). EDP Sciences.

Choung, J., Han, S., 2016. A novel approach to predict mooring chain fatigue considering out-of-plane and in-plane bending effects. In: Proceedings of 1st International Conference on Ships and Offshore Structures, Hamburg, Germany.

Choung, J., Lee, J. B., 2018. Study on prediction of stresses by out-of-plane and in-plane bending moments in offshore mooring chain. Ships and Offshore Structures, 13(sup1), 98-112.

Clark, C. E., Paredes, G. M., 2018. Effects of Co-Located Floating Wind-Wave Systems on Fatigue Damage of Floating Offshore Wind Turbine Mooring Cables. In: Proceedings of ASME 2018 1st International Offshore Wind Technical Conference.

de Laval, G., 1971. Fatigue tests on anchor chain cable. In: Proceedings of Offshore Technology Conference, OTC 1503, Dallas, Texas.

Dirlik T.,1985. Application of computers in fatigue analysis. Ph.D. thesis. UK: University of Warwick.

DNV OS E301, 2001. Offshore Standard DNV-OS-E301: Position Mooring. Det Norske Veritas and Germanischer Lloyd SE.

DNVGL, 2019. FEATURE DESCRIPTION: Sesam-Software suite for hydrodynamic and structural analysis of ships and offshore structures. Det Norske Veritas and Germanischer Lloyd SE.

DNVGL OS E301, 2015. Offshore standard DNVGL-OS-E301: Position mooring. Det Norske Veritas and Germanischer Lloyd SE.

DNVGL OS E302, 2015. Offshore Standard DNVGL-OS-E302: Offshore Mooring Chain. Det Norske Veritas and Germanischer Lloyd SE.

Du, J., Wang, S., Chang, A., Li, H., 2016. An investigation on low frequency fatigue damage of mooring lines applied in a semi-submersible platform. Journal of Ocean University of China, 15(3), 438-446.

Fontaine, E., Kilner, A., Carra, C., Washington, D., Ma, K. T., Phadke, A. Kusinski, G., 2014. Industry survey of past failures, pre-emptive replacements and reported degradations for mooring systems of floating production units. In: Proceedings of Offshore Technology Conference.

Fujiwara, T., 2018. Semi-Submersible Floater's VIM Simulation Method for Mooring Line Safety Assessment. In: Proceedings of ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering. American Society of Mechanical Engineers Digital Collection.

Fu TT, Cebon D., 2000. Predicting fatigue lives for bi-modal stress spectral densities. International journal of fatigue, 22:11–21.

Gao, Z., Moan, T., 2006. Wave-induced fatigue damage of mooring chain under combined non-gaussian low and wave frequency loads. In: Proceedings of 25th international conference on offshore mechanics and arctic engineering. American Society of Mechanical Engineers Digital Collection.

Gao, Z., Moan, T., 2007. Fatigue damage induced by nonGaussian bimodal wave loading in mooring lines. Appl. Ocean Res. 29, 45–54.

Gao, Z., Moan, T., 2008. Frequency-domain fatigue analysis of wide-band stationary Gaussian processes using a trimodal spectral formulation. International Journal of Fatigue, 30(10-11), 1944-1955.

Garza-Rios, L.O., Bernitsas, M.M., Nishimoto, K., 1997. Catenary Mooring Lines with Nonlinear Drag and Touch down. University of Michigan.

Han, J. S., Kim, Y. H., Son, Y. J., Choi, H. S., 2010. A comparative study on the fatigue life of mooring systems with different composition. Journal of Hydrodynamics, 22(1), 435-439.

Hanzawa, M., Yokota, H., Toda, Y., and Yokoyama, K., 1981. Fatigue Behaviour of Large-Diameter Ropes, In: Proceedings of Offshore Technology Conference.

Hiroshima, T., Sawa, T., 1995. Three-dimensional elastoplastic finite-element analysis of link chains in chain hoist subjected to combined loads of torsion and impact tension. Nippon Kikai Gakkai Ronbunshu, A Hen/Transactions of the Japan Society of Mechanical Engineers, Part A, 61(591), 2442-2449.

Hobbs, R. E., Ridge, I. M.L., 2005. Torque in mooring chain. Part 1: background and theory. The Journal of Strain Analysis for Engineering Design, 40(7), 703-713.

Horde, G.O., Moan, T., 1997. Fatigue and overload reliability of mooring systems. In: Proceedings of the Seventh International Offshore and Polar Engineering Conference. International Society of Offshore and Polar Engineers, Honolulu, USA.

Hou, H. M., Dong, G. H., Xu, T. J., Zhao, Y. P., Bi, C. W., and Gui, F. K., 2018. Fatigue reliability analysis of mooring system for fish cage. Applied Ocean Research, 71, 77-89.

HSE, 1992. Review of Mooring Incidents in the Storms of October 1991 and January 1992, HSE Offshore Technology Report – OTO 92 013.

Huang, C. C., Pan, J. Y., 2010. Mooring line fatigue: A risk analysis for an SPM cage system. Aquacultural engineering, 42(1), 8-16.

Huang, S., Sheng, S., Gerthoffert, A., Cong, Y., Zhang, T., Wang, Z., 2019. Numerical design study of multipoint mooring systems for the floating wave energy converter in deep water with a sloping bottom. Renewable energy, 136, 558-571.

Huang, W., Liu, H. X., Shan, G. M., Hu, C., 2011. Fatigue analysis of the taut-wire mooring system applied for deep waters. China Ocean Engineering, 25(3), 413.

Humeau, C., Davies, P., Smeets, P., Engels, T. A. P., Govaert, L. E., Vlasblom, M., Jacquemin, F., 2018. Tension fatigue failure prediction for HMPE fibre ropes. Polymer Testing, 65, 497-504.

Høeg, C., Zhang, Z., 2018. The influence of different mooring line models on the stochastic dynamic responses of floating wind turbines. In Journal of Physics: Conference Series (Vol. 1037, No. 6, p. 062016). IOP Publishing.

Ibekwe, A., Sorensen, K., Fernández, J., Arredondo, A., Mena, A., (2018). Remnant Life Assessment of Bonga FPSO and SPM Mooring Chains. In: Proceedings of ASME 2018 37th

International Conference on Ocean, Offshore and Arctic Engineering. American Society of Mechanical Engineers Digital Collection.

ISO, 2013. Petroleum and natural gas industries - Specific requirements for offshore structures - Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units. ISO 19901-7.

Jiao G, Moan T., 1990. Probabilistic analysis of fatigue due to Gaussian load processes. Probabilistic Engineering Mechanics, 5(2):76–83.

Kaiser, M. J., 2019. Decommissioning Forecasting and Operating Cost Estimation. Elsevier.

Kim, H., Choung, J., Jeon, G. Y., 2014. Design of mooring lines of floating offshore wind turbine in Jeju offshore area. In: Proceedings of ASME 2014 33rd International Conference on Ocean, Offshore and Arctic Engineering. American Society of Mechanical Engineers.

Kim, Y., Kim, M. S., Park, M. J., 2018. Fatigue analysis on the mooring chain of a spread moored FPSO considering the OPB and IPB. International Journal of Naval Architecture and Ocean Engineering, 11, 178-204.

Kvitrud, A., 2014. Lessons learned from Norwegian mooring line failures 2010–2013. In: Proceedings of the ASME 2014 33rd International Conference on Ocean, Offshore and Arctic Engineering. OMAE2014–23095. San Francisco, California, USA.

Lardier, J., Moan, T., Gao, Z., 2008. Fatigue reliability of catenary mooring lines under corrosion effect. In: Proceedings of the ASME 27th International Conference on Ocean, Offshore and Arctic Engineering. OMAE2008. Estoril, Portugal.

Larsen, C.E., Lutes, L. D., 1991. Predicting the fatigue life of offshore structures by the single-moment spectral method. Probabilistic Engineering Mechanics, 6(2): 96-108.

Larsen, K. and Mathisen, J., 1996. Reliability-Based Fatigue Analysis of Mooting Lines. In: Proceedings of the 15th International Conference on OMAE.

Lassen, T., Aarsnes, J. and Glomnes, E., 2014. Fatigue Design Methodology for Large Mooring Chains Subjected to Out-of-Plane Bending. In: Proceedings of 33rd Internation Conference on Ocean, Offshore and Arctic Engeneering, San Diego.

Lassen, T., Arana, J.L., Henriksen, J., Holthe, N.K., 2005. Crack growth in high strength chain steel subjected to fatigue loading in a corrosive environment. In: Proceedings of OMAE2005. 24th International Conference on Offshore Mechanics and Arctic Engineering. OMAE2005-67242. Halkidiki, Greece.

Lassen, T., Storvoll, E. and Bech, A., 2009. Fatigue Life Prediction of Mooring Chains subjected to Tension and Out of Plane Bending. In: Proceedings of 28th Internation Conference on Ocean, Offshore and Arctic Engeneering, Honolulu.

Lassen, T., Syvertsen, K., 1997. Fatigue reliability and life-cycle cost analysis of mooring chains. Int. J. Offshore Polar Eng. 7 (2), 135–140.

Lereim, J., 1985. Summary of the 4-year research project: anchor chain cables offshore. In: Proceedings of 17th Offshore Technology Conference, Houston, Texas.

Li, C. B., Choung, J., Noh, M. H., 2018. Wide-banded fatigue damage evaluation of Catenary mooring lines using various Artificial Neural Networks models. Marine Structures, 60, 186-200.

Li, H., Du, J., Wang, S., Sun, M., Chang, A., 2016. Investigation on the probabilistic distribution of mooring line tension for fatigue damage assessment. Ocean Engineering, 124, 204-214.

Lian, Y., Liu, H., Zhang, Y., Li, L., 2017. An experimental investigation on fatigue behaviors of HMPE ropes. Ocean Engineering, 139, 237-249.

Low, Y. M., Cheung, S. H., 2012. On the long-term fatigue assessment of mooring and riser systems. Ocean Engineering, 53, 60-71.

Lucht, W. A., Donecker, F. W., 1977. Factors Affecting Wire Rope Life In Amarine Environment. In: Proceedings of Offshore Technology Conference.

Luo, M., Heyl, C., 2017. Numerical study on the out-of-plane bending (OPB) behaviors of studless mooring chain links in fairlead structures. In: Proceedings of the 27th International Ocean and Polar Engineering Conference. International Society of Offshore and Polar Engineers.

Lutes, L. D., Corazao, M., Hu, S. L. J., Zimmerman, J., 1984. Stochastic fatigue damage accumulation. Journal of Structural Engineering, 110(11): 2585-2601.

Ma, K.T., Duggal, A., Smedley, P., L'Hostis, D., Shu, H., 2013. A historical review on integrity issues of permanent mooring systems. OTC 24025. In: Proceedings of Offshore Technology Conference, Houston, Texas, USA.

Madsen HO, Krenk S, Lind NC.,1986. Methods of structural safety. Englewood Cliffs: Prentice-Hall.

Majhi, S., D'Souza, R., 2013. Application of lessons learned from field experience to design, installation and maintenance of FPS moorings. In: Proceedings of Offshore Technology Conference.

Mamiya, E. N., Castro, F. C., Ferreira, G. V., Nunes Filho, E. L. S. A., Canut, F. A., Neves, R. S., Malcher, L., 2019. Fatigue of mooring chain links subjected to out-of-plane bending: Experiments and modeling. Engineering Failure Analysis, 100, 206-213.

MARINTEK, 2012. MIMOSAUser’s Documentation,Version6.3.

Marsh, F.W., Thurston, R. C. A., 1961. investigation of stress distribution in stud link anchor cable. Report IR61-46, Department of Mines and Technical Surveys, Ottawa, Canada.

Mathisen, J., Larsen, K., 2004. Risk-based inspection planning for mooring chain. Journal of Offshore Mechanics and Arctic Engineering, 126, 250-257.

Melis, C., Jean, P. and Vargas, P., 2005. Out-of-plane bending testing of chain links. In: Proceedings of the 24th Internation Conference on Ocean, Offshore and Arctic Engeneering, Halkidiki.

OCIMF, 2013. Mooring equipment guidelines.

Offshore Magazine, 1997. How offshore drilling units evolved.

Olagnon, M., Guédé, Z., 2008. Rainflow fatigue analysis for loads with multimodal power spectral densities. Marine Structures 21, 160-176.

Palin-Luc, T., Pérez-Mora, R., Bathias, C., Domínguez, G., Paris, P. C., Arana, J. L., 2010. Fatigue crack initiation and growth on a steel in the very high cycle regime with sea water corrosion. Engineering Fracture Mechanics, 77, 1953-1962.

Paris, P.C., Erdogan, F., 1963. A critical analysis of crack propagation laws. J Basic Eng 85(4), 528–534.

Pham, H. D., Cartraud, P., Schoefs, F., Soulard, T., Berhault, C., 2019. Dynamic modeling of nylon mooring lines for a floating wind turbine. Applied Ocean Research, 87, 1-8.

Pillai, A. C., Thies, P. R., Johanning, L., 2018. Comparing Frequency and Time Domain Simulations for Geometry Optimization of a Floating Offshore Wind Turbine Mooring System. In: Proceedings of ASME 2018 1st International Offshore Wind Technical Conference.

Pérez-Mora, R., Palin-Luc, T., Bathias, C., Paris, P. C., 2015. Very high cycle fatigue of a high strength steel under sea water corrosion: A strong corrosion and mechanical damage coupling. International Journal of Fatigue, 74, 156-165.

Qiao, D., Yan, J., Ou, J., 2014. Fatigue analysis of deepwater hybrid mooring line under corrosion effect. Polish Maritime Research, 21(3), 68-76.

Qiao, D., Zheng, C., Li, B., Ou, J., Zhai, G., 2010. Comparative analysis on fatigue damage of deepwater hybrid mooring line. In: Proceedings of ASME 2010 29th International Conference on Ocean, Offshore and Arctic Engineering (pp. 443-452). American Society of Mechanical Engineers Digital Collection.

Rice, S.O., 1954. Mathematical Analysis of Random Noise, papers on Noise and Stochastic Processes, ed. N. Wax, Dover, New York.

Rampi, L., Bignonnet, A., Le Cunff, C., Bourgin, F., Vargas, P., 2016. Chain out of plane bending (OPB) fatigue joint industry project (JIP) FEA results and multiaxiality study results. In: Proceedings of ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering.

Rampi, L., Dewi, F., Francois, M., Gerthoffert, A., Vargas, P., 2016a. Chain out of plane bending (OPB) fatigue joint industry project (JIP) static test program and OPB interlink stiffness. In: Proceedings of ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering.

Rampi, L., Gerthoffert, A., Francois, M., Bignonnet, A., Vargas, P., 2016b. Chain out of plane bending (OPB) fatigue joint industry project (JIP) fatigue test program results and methodology. In: Proceedings of ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering.

Rampi, L., Vargas, P., 2006. Fatigue testing of out-of-plane bending mechanism of chain links. In proceedings of: 25th International Conference on Offshore Mechanics and Arctic Engineering.

Ridge, I. M. L., 2008. Torsional characterization of ropes used offshore. Journal of Strain Analysis 43(2),121–139.

Ridge, I. M. L., 2009. Tension–torsion fatigue behaviour of wire ropes in offshore moorings. Ocean Engineering, 36(9-10), 650-660.

Ridge, I. M.L., Hobbs, R. E., 2005. Torque in mooring chain. Part 2: experimental investigation. The Journal of Strain Analysis for Engineering Design, 40(7), 715-728.

Ridge, I. M. L., Hobbs, R. E., Fernandez, J., 2006. Predicting the torsional response of large mooring chains. In Offshore Technology Conference. Offshore Technology Conference.

Ridge, I., Smedley, P., Hobbs, R., 2011. Effects of twist on chain strength and fatigue performance: small scale test results. In proceedings: 30th International Conference on Ocean, Offshore and Arctic Engineering.

Sedghi, H., Kimiaei, M., 2018. Effects of Mooring Line Design Parameters on the Line Dynamics and Fatigue Response of Subsea Mooring Lines. In: Proceedings of ASME 2018 37th International Conference on Ocean, Offshore and Arctic Engineering. American Society of Mechanical Engineers Digital Collection.

ter Brake, E., van der Cammen, J. and Uittenbogaard, R., 2007. Calculation Methodology of out of Plane Bending of Mooring Chains. In: proceedings of 26th Internation Conference on Ocean, Offshore and Arctic Engeneering, San Diego.

Thies, P. R., Johanning, L., Harnois, V., Smith, H., Parish, D.N., 2014. Mooring line fatigue damage evaluation for floating marine energy converters: Field measurements and prediction. Renewable Energy, 63: 133-144

Thorpe, T. W., and Rance, A., 1983. The Tensile Fatigue of Wire Rope: A New Approach. In: proceedings of Offshore Technology Conference.

Toro GR., 1984. Probabilistic analysis of combined dynamic responses PhD. Thesis Dept of Civil Engineering: Stanford University.

Tovo, R., 2002. Cycle distribution and fatigue damage under broad-band random loading. International journal of fatigue .24(11):1137–47.

Trarieux, F., Lyons, G. J., 2008. Fatigue damage assessment using a bandwidth parameter for VIV applied to the Foinaven dynamic umbilical. In: proceedings of ASME 2005 24th International Conference on Offshore Mechanics and Arctic Engineering (pp. 65-77). American Society of Mechanical Engineers Digital Collection.

Trarieux, F., Lyons, G. J., Patel, M. H., 2006. Investigations with a bandwidth measure for fatigue assessment of the Foinaven dynamic umbilical including VIV. Engineering structures, 28(12), 1671-1690.

van Helvoirt, L.C., 1982. Static and fatigue tests on chain links and chain connecting links. In: Proceedings of Offshore Technology Conference,. OTC 4179,Houston, Texas.

Vargas, P.M., Hsu, T.M., Lee, W.K., 2004. Stress concentration factors for stud-less mooring chain links in fairleads. In: Proceedings of 23rd International Conference on Offshore Mechanics and Arctic Engineering, Vancouver, British Columbia, Canada.

Vargas, P.M. Jean, P., 2005. FEA of Out-of-Plane Fatigue Mechanism of Chain Links. In proceedings of 24th Internation Conference on Ocean, Offshore and Arctic Engeneering, Halkidiki.

Wirsching, P.H., & Light, M.C., 1980. Fatigue under wide band random stresses. Journal of the Structural Division, 106(7): 1593-1607.

Wu, Y., Wang, T., Eide, Ø., Haverty, K., 2015. Governing factors and locations of fatigue damage on mooring lines of floating structures. Ocean Eng. 96, 109–124.

Wu, W. H., Lv, B. C., Yue, Q. J., Zhang, Y. T., Lin, Y., 2017. Research on analytical method of fatigue characteristics of Soft Yoke Mooring System based on full-scale measurement. China Ocean Engineering, 31(2), 230-237.

Xu, T.J., Zhao, Y.P., Dong, G.H., Bi, C.W., 2014. Fatigue analysis of mooring system for net cage under random loads. Aquacult. Eng. 58, 59–68.

Yang, S. H., Ringsberg, J. W., Johnson, E., 2014. Analysis of Mooring Lines for Wave Energy Converters: A Comparison of De-Coupled and Coupled Simulation Procedures. In ASME 2014 33rd International Conference on Ocean, Offshore and Arctic Engineering.

Yang, S. H., Ringsberg, J. W., Johnson, E., Hu, Z., Palm, J., 2016. A comparison of coupled and de-coupled simulation procedures for the fatigue analysis of wave energy converter mooring lines. Ocean Engineering, 117, 332-345.

Yang, S. H., Ringsberg, J. W., Johnson, E., Hu, Z., 2017. Biofouling on mooring lines and power cables used in wave energy converter systems—analysis of fatigue life and energy performance. Applied Ocean Research, 65, 166-177.

Zhao, W., Baker, M. J., 1992. On the probability density function of rainflow stress range for stationary Gaussian processes. International Journal of Fatigue, 14(2), 121-135.